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Forthcoming Events.

JANUARY 21.

Wolverhampton Engineering and Scientific Club:—Ordinary meeting. "Rust-resisting Steel," Paper by Dr. W. H. Hatfield, D.S.O.

JANUARY 22.

Swansea Technical College Metallurgical Society:—General meeting. "The Manufacture of Steel for Tinbars," Paper by Dr. P. M. Macnair, B.Sc., A.I.C.

JANUARY 26.

Royal Society of Arts:—Ordinary meeting in London. "British and American Practice in the Working of Hot and Cold Metals," Paper by F. W. Spencer.

Institution of Production Engineers:—General meeting in London.

Institute of British Foundrymen.

JANUARY 22.

Birmingham, Coventry and West Midlands Branch:—Annual dinner.

Scottish Branch:—Ordinary meeting at Glasgow. "Changes Produced in Cast Iron by Heat Treatment," Paper by J. H. Andrew.

Falkirk Section:—Ordinary meeting. "Some Experiences with Cupolas," Paper by H. Cowan, B.Sc.

East Midlands Branch:—Annual meeting. Presidential address and Short Paper Competition.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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The Use of Nickel in Cast Iron.

Whether any advantage is to be derived from the addition of nickel to cast iron is a matter which from time to time excites considerable controversy amongst British founders. Little independent British investigation has been carried out to show whether the benefits, if any, outweigh the extra cost involved.

For some years past Papers have been received from the United States showing that the action of nickel is beneficial, but practical trials in English foundries have invariably proved disappointing. The result is a not unnatural tendency on the part of British founders to view American results with a certain amount of reserve, particularly when it is remembered that the production of nickel, if not a monopoly, is in the hands of a very small number of producers.

The good faith of American investigators, of course, is not even remotely in question. The reasons for the difficulties found on this side are easily seen. American irons differ in character from British, and melting practice in the two countries also differs considerably. Many British observers who have been to the States say that in mechanical properties American cast irons do not equal British. What has been found true in other fields of development applies to cast iron. Results determined for the one country cannot be applied to the other without confirmatory experimental work, and no founder should attempt to use nickel for commercial runs without either experimenting himself or preferably making himself fully conversant with the latest authoritative work that has been done in this field in this country. The article in this issue reviews recent American work, and gives the results of personal observation. It is satisfactory to note that the remaining measures required to satisfy the British founder are now being undertaken.

It should be borne in mind that the addition of nickel to cast iron is well established in this country for the definite purpose of making it non-magnetic. We have not personally had any practical experience of adding nickel to cast iron, but when we have added to a molten bath of steel, it acts a little like a dose of iron ore, as its principal impurity is nickel oxide. This factor should have the close consideration of future investigators.

Some time ago the Cast Iron Research Association issued the results of some work on nickel in white iron. With the active support of the International Nickel Company, the Metallurgical Department of the University of Birmingham is arranging to study the influence of nickel on grey iron. The B.C.I.R.A., with the support of the leading nickel producers, will actively co-operate in this work, in connection with which a small committee is being formed.

The results of this work, arrived at by the collaboration of two impartial authorities, the University and the Research Association, will command the confidence of, and will be generally accepted by all founders, and should bring to an end the present unsatisfactory position, for on the one hand we have reports of satisfactory American practice, examples of which are given elsewhere in this issue, and, on the other hand, dissatisfaction openly expressed by a number of founders who have endeavoured to produce satisfactory castings in which a percentage of nickel is specified.

Those interested may rest assured that the work now being initiated will embody both laboratory tests and melts on a commercial scale, and if any form of nickel alloy could be more readily incorporated with advantage in cast iron, as some American experience would appear to indicate, we trust that the alloy will be made available.

Birmingham Foundrymen Visit B.C.I.R.A. Headquarters.

Members of the Birmingham, Coventry and West Midland Branch of the Institute of British Foundrymen paid a visit to the new headquarters of the British Cast Iron Research Association at 24, St. Paul's Square, Birmingham, on January 6, and were shown over the various departments by members of the staff. The previous day a company of about 40, representing members of the Association in the Midlands, made a similar inspection of the premises. During the tour Mr. F. J. Cook, M.I.Mech.E., who is a member of Council of the Association, gave some particulars of interest to the visitors regarding the new premises and the progress of the organisation. A great deal of the research work hitherto carried out had been done at the Universities, he said. The Association engaged men suitable for such work to proceed on lines conforming to the Association programmes under the direction of their respective professors. This course had been adopted at Sheffield, Manchester and Birmingham. There was, however, a large amount of work which the Association required to be done under its own direct supervision, in addition to minor researches needed to overcome the difficulties which were met with from day to day in foundry practice, and also to carry out investigations into castings inside the foundries themselves. The Association was fortunate in possessing members who were liberal enough to place their foundries and the necessary skilled men at their disposal for this particular kind of research, and in the past five years during which the Association had existed the value of these operations amounted to many thousands of pounds. In this connection Mr. Cook emphasised that the Association was acting in a purely co-operative capacity, and the more members assisted them in this respect the better able would they be to render help in arriving at solutions to various problems in foundry practice.

The New Headquarters.

Speaking of the new headquarters' development, Mr. Cook recalled that at the start the Association experienced great difficulty, owing to the slump in trade, in obtaining a sufficient amount of money to proceed on any scale. But in due course a gratifying enrolment of members enabled them to secure funds which allowed of certain work being undertaken in their own building, as well as at the Universities. The Association was able to obtain a small laboratory at Birmingham. This was already equipped, and a good deal of useful work was done there, although the place was anything but ideal, and not in close proximity to the then headquarters in New Street. The present building in St. Paul's Square was then found to be available. It is not a pretentious building, but is compact and serviceable, and will permit of useful work being done in a convenient manner. The front contains two storeys with a basement. The ground floor is divided into a library and information bureau, which is open to members of each class, behind which is the microscopic laboratory and photographic department. On the first floor of the front part of the premises there is the directors' room and other offices. At the rear there is a three-storey building, the ground floor of which is devoted to pure research work.

Present Investigations.

At the moment two special investigations are being made; one in regard to malleable irons, and the other as to heat resisting irons. Among the plant is a Chevenard dilatometer, an instrument for measuring the effects of temperature up to 1,000 deg. C. on different classes of metal. On the first floor is a machine shop for preparing specimens and for carrying out physical tests. The testing machines include repeated impact, Brinell hardness, tensile, transverse, etc. The impact machine is believed to be one of three only in the country at present. It is particularly valuable for testing high quality irons, and a number of English foundries turning out high quality irons have shown an interest in this new machine. The second floor consists of a chemical laboratory, which is well equipped with furnaces and apparatus for taking carbons by the combustion method and other estimations on cast irons.

The premises have been examined by the Department for Scientific and Industrial Research, and have, as Mr. Cook said, received its blessing. To equip the building a sum of £1,200 has been expended, and to complete the minimum of requirements another £300 is needed. The five years' period during which the Government made a grant *pro rata* with the subscriptions ended last June, and as a result of the progress made the Government are now continuing the grant for another three years, and at the rate of 10s. for every 20s. subscribed the two following years. When the Association was formed it had to raise a minimum of £2,500 to secure a grant; now the minimum required to earn Government assistance is £4,000.

The Director and Consultant were unavoidably absent on this occasion, but, in addition to Mr. Cook, the following members of the staff took the party round the different departments:—Mr. E. R. Taylor, F.I.C., Mr. E. Morgan, M.Sc. (investigators), Mr. G. Murray (chemist), Mr. L. W. Bolton (metallographist), and Mr. H. G. Clarke (mechanical testing department). Mr. F. K. Neath, B.Sc. (hon. secretary of the local Branch of the I.B.F.), who is in charge of the library and information bureau, explained the system adopted for collating and indexing information, and mentioned that the Association had prepared some 30 to 40 translations for Associate members during the last two years. Apart from periodicals and a fairly complete and representative library, any articles of importance appearing in technical publications are abstracted and indexed. If considered desirable the attention of the research staff is drawn to these articles. Further, every patent specification, technical article, trade catalogue, etc., assuming it is of interest, is filed under the name of the author, number of patent or firm concerned, and classified. The method of classification is so simplified that information on any point is easily ascertainable; that is, supposing it is available. Mr. Neath, referring to the three classes of members, pointed out that Associate membership was intended for foundry managers, foremen, works' chemists, etc., who were admitted to membership at a reduction of 10s. in the 30s. subscription if they were members of the I.B.F.

Some important research work, continued Mr. Neath, was being done in malleable cast irons, especially in relation to total carbon and cooling rate; and in regard to heat-resisting tests they hoped shortly to ascertain whether certain irons of high quality would stand given high temperatures under service. This particular work would be extremely useful in furnishing information as to resistance to super-heated steam and irons employed in Diesel engine work, where the inside of the piston was subjected to a very high temperature, and so on. Research work was still going on by their own men at Manchester and Sheffield Universities, and also at the National Physical Laboratories at Teddington. Twelve months ago the Association amalgamated with the Foundry Technical Institute at Falkirk, which formed the Scottish Laboratory. The work there largely concerned light castings, that area being the centre of this particular side of the industry. It would now be possible to do something towards centralising the work of the Association, and it was hoped to do much more research work at the foundries of members through the research assistants and their staffs.

During the inspection of the machine and testing shop test bars of ½ in. to 3 in. were shown, and it was explained that the effect of casting at different temperatures and thicknesses was being investigated. In the library a sample of Indian cyanite was shown, together with a similar piece which had been calcined. Easily crushed, and mixed with clay, it forms a plastic refractory which has great possibilities. There are considerable deposits of this cyanite in India, and it is said to be in practically a pure state. The American product is, of course, in a much more impure form. Curiously enough, an Indian member of the Association wrote calling attention to this cyanite at the same time that tests were being made in America. It is mixed with up to 25 per cent. of clay bond, and has a future before it. The thanks of the party were conveyed to the Association and the gentlemen acting as guides by Mr. D. H. Wood, President of the Birmingham Branch of the I.B.F.

The Manufacture of Iron Castings for Petrol Engines.

By W. J. Molyneux.

(*Continued from page* 31.)

Coremaking.

This is a branch of the cylinder founders' business that offers almost endless possibilities for time-saving, and although much has been done in the economic production of oil-sand cores, there is still far too much of the foundry practice of 20 years ago in evidence, even in some otherwise well-appointed foundries. One has only to glance round the core rooms to see skilled workers literally wasting their time in finishing cores due to faulty draws, cleaning out loose sand from awkward corners in coreboxes, rubbing of dried cores, blacking with brushes, etc., etc., to realise what can be saved by the expenditure of a little more money at the outset and the employment of

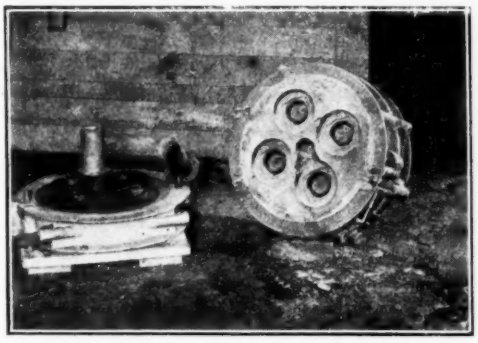


FIG. 17.—TWO PARTS OF THE MOULD WITH FOUR CORES IN THE DRAG. ALSO A FINISHED CYLINDER AND A ROUGH CASTING WITH STRAINER CORES.

a first-class man to plan every operation beforehand and design the equipment to avoid this useless labour. It is possible to-day to produce all the cores for any ordinary cylinder (1) by female labour; (2) without any hand tooling whatever after the corebox is removed; (3) without the necessity for rubbing the dried cores; and (4) at an exceedingly cheap rate, and at the same time enable the coremakers to earn big wages and work under excellent conditions.

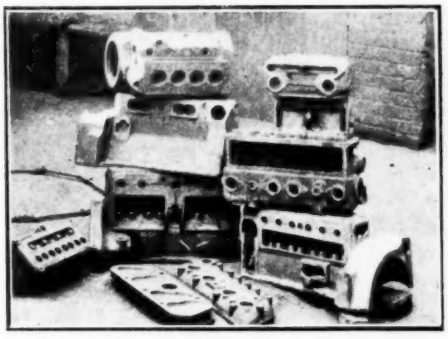


FIG. 18.—GROUP OF CYLINDERS AND HEADS.

Where quantities justify the expense, wood coreboxes should not be used, but where this is not the case it will be found that a good hard mahogany will give good service, especially if reinforced with aluminium in the delicate parts. It is also excellent practice to face the corebox joints with aluminium about $\frac{1}{2}$ in. thick, which can be machined over after final assembly on a vertical milling or similar machine.

In Figs. 22 to 33 are shown the making of the cores for a small 4-bore side-by-side valve cylinder that has heads and inlet pipes and ports all cast in, all the cores are produced by female labour. The boxes are so constructed that there is no bedding in of loose pieces with mallets, all wires can be easily put in, and every core can be made without patching up of any kind whatever. The cores strip clean from the corebox, are dried, blacked and assembled. Each operation was carefully planned beforehand, and the coreboxes designed and machined by tool makers.

Pouring Cylinder Castings.

Some difference of opinion exists regarding the pouring of cylinder castings. Perhaps the most favoured method is to pour directly down the cylinder boxes. This is an excellent way for comparatively plain cylinders, but with more com-

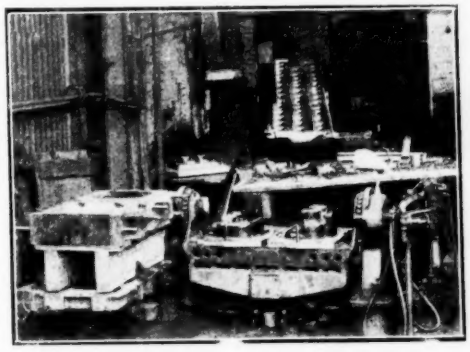


FIG. 19.—TWO-BORE LORRY CYLINDER-PATTERN PLATES MOULDED IN PAIRS ON OSBORN MACHINE.

plicated castings, such as those with much pipe and valve work in and for those cast in one piece with the crankcase, pouring very fast through numerous small runners extending round three sides of the casting produces the best results. A pouring speed of 8 seconds per 1 cwt. is a satisfactory rate. Where the cylinders are densened it is inadvisable to pour direct down the cylinder bores.

Where the life of the cylinder is of more importance than top speeds in machining, the usual practice is to use an iron as hard as pos-

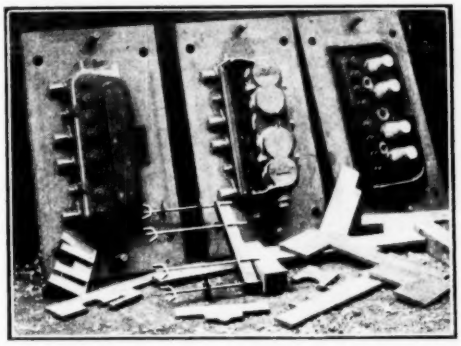


FIG. 20.—A SET OF PATTERN PLATES, CORE GAUGES, ETC., FOR 4-BORE CYLINDER.

sible consistent with moderate machining speeds in all parts of the casting—of course, taking care to avoid the possibility of white iron in the thin jacket or crankcase parts. The thickness in these cylinders varies from $\frac{5}{16}$ in. in the jackets and pipes, etc., to $\frac{1}{2}$ in. or $\frac{5}{8}$ in. in the cylinder bores, and up to $1\frac{1}{2}$ in. or even more in some of these bosses. It may be said in ordinary practice the degree of hardness varies inversely with the thickness of the section, so that with the cylinder bores being comparatively thick and in the hottest part of the mould when cast, the heat is radiated

much more slowly than in some of the remote parts of the casting. This, together with the fact that large bosses are often attached to the cylinder walls, leads to the production of a somewhat softer iron in the very place where maximum

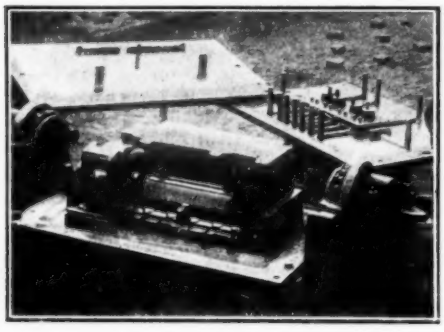


FIG. 21.—GROUP OF 4-BORE CYLINDER AND CRANKCASE PATTERN PLATES ON OSBORN MACHINE. SOME 7,000 CASTINGS HAD BEEN PRODUCED FROM THIS PATTERN WHEN THE PICTURE WAS MADE.

hardness is desirable. It has been stated by H. B. Swan, of Detroit, that a cylinder bore ⅜ in. thick is softer, due to cooling conditions, than a 1-in. square bar cast separate from the same ladle of iron.

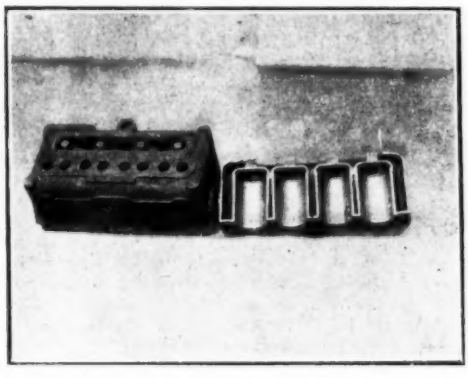


FIG. 22.—A 63-M/M BORE CYLINDER CASTING.

This was very pronounced in an experience the author had in 1919 and 1920 with a 4-bore cylinder that had a large thin crankcase cast on. These castings were being made in several foundries in this country and on the Continent. In some of these castings the cylinders were much too soft to wear satisfactorily, and in others, where the cylinders were reasonably hard, difficulty was experienced in machining thin parts towards the outsides of the castings, but what was even worse, several of these castings developed cracks in the jacket and crankcases in service. This led to experiments with hardened cylinder bores, a practice eventually made standard. To obtain this hard surface each cylinder bore core is provided with two half-round denseners which extend to within ¼ in. of each end. These denseners are

FIG. 24.—TWO PATTERN PLATES ON 403 OSBORN MACHINE. ONE OF 2 PLATES FOR MAKING GREEN-SAND TOPS, WHICH ARE SEEN IN FOREGROUND.

used over and over again, and are made quite cheaply from plate patterns on jar ram machines.

The advantages of this method are: (1) The cylinder bores are of uniform hardness throughout. Many cylinder founders use local denseners where heavy bosses adjoin the cylinder walls.

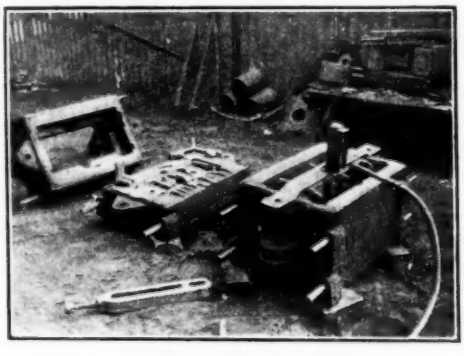


FIG. 25.—THE CYLINDER SHOWN IN FIG. 22 IN PROCESS OF CORING. NOTE THE GAS DRIER FOR REACHING ALL PARTS OF THE MOULD.

This practice is undesirable, as it is usual to-day to ream-finish a cylinder bore instead of grinding, and this is rendered difficult due to the various degrees of hardness, also in use the wear on the walls and pistons is uneven; (2) the cylinder bores are the hardest part of the casting; a Brinell number of over 200 is easily maintained; (3) porous cylinders are almost unknown; (4) the machine-shop rejects are much less; a most successful run was experienced in 1924 using this method; an overall scrap of 3 per

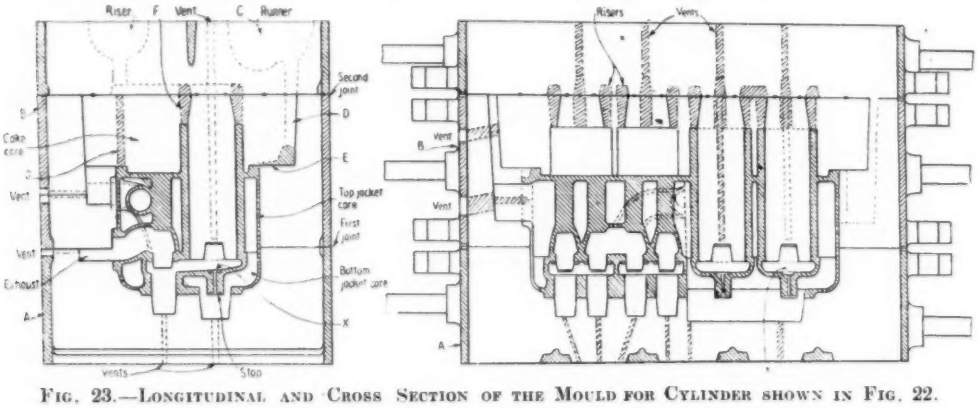


FIG. 23.—LONGITUDINAL AND CROSS SECTION OF THE MOULD FOR CYLINDER SHOWN IN FIG. 22.

cent. was maintained for the year; and (5) although boring is somewhat slower, other parts of the castings can be machined at a much higher speed.

Most foundries have pet ideas regarding their cylinder mixtures, and there is some conflict of opinion regarding the most suitable composition. In this country in particular some of the elements—notably phosphorus—vary considerably. Some founders turning out first-class work believe

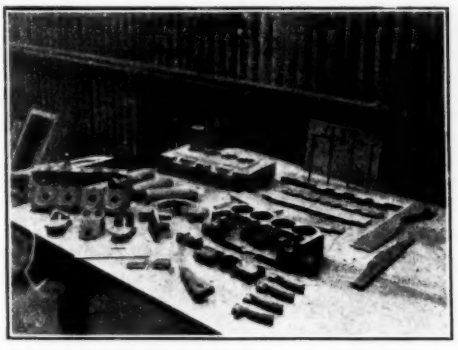


FIG. 26.—GROUP OF CORES AND GAUGES FOR THE CYLINDER SHOWN IN FIG. 22.

in a phosphorus-content of up to 1.2 per cent., while others regard 0.5 per cent. as the maximum. The author has had satisfactory results with irons of the following composition: TC, about 3.2; Si, 1.4 to 2.0 for hardened bores; S, 0.1 maximum; Mn, 0.5; and P, 0.4 to 0.5 per cent.

It is of paramount importance that the cupola practice be of the best. Cupolas up to 3 ft. dia. are most suitable, and this metal must have sufficient superheat to allow of its being in good condition after tapping into Bull ladles, and probably carried in shanks for considerable distances.

In conclusion, the author's thanks are due to Messrs. Iliffe & Sons for their permission to use

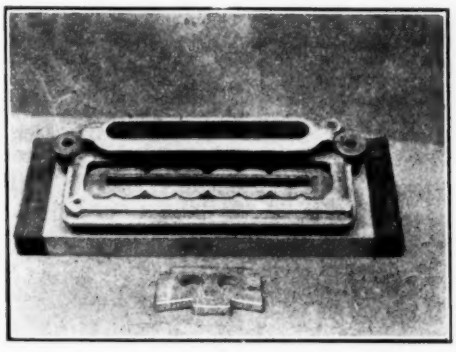


FIG. 27.—VIEW OF BOTTOM JACKET CORE-BOX. IT IS ARRANGED TO AVOID THE BEDDING OF ALL LOOSE PIECES.

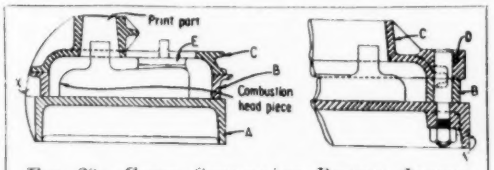


FIG. 28.—CROSS SECTION OF BOTTOM JACKET BOX SEEN IN FIG. 27.—NOTE CURVED RIBS MARKED × TO ENABLE THE OPERATION OF "ROLL" THE CORE-BOX INSTEAD OF LIFTING.

certain illustrations, also the directors of Messrs. Dormans, of Stafford, for their permission to use certain of the photographs.

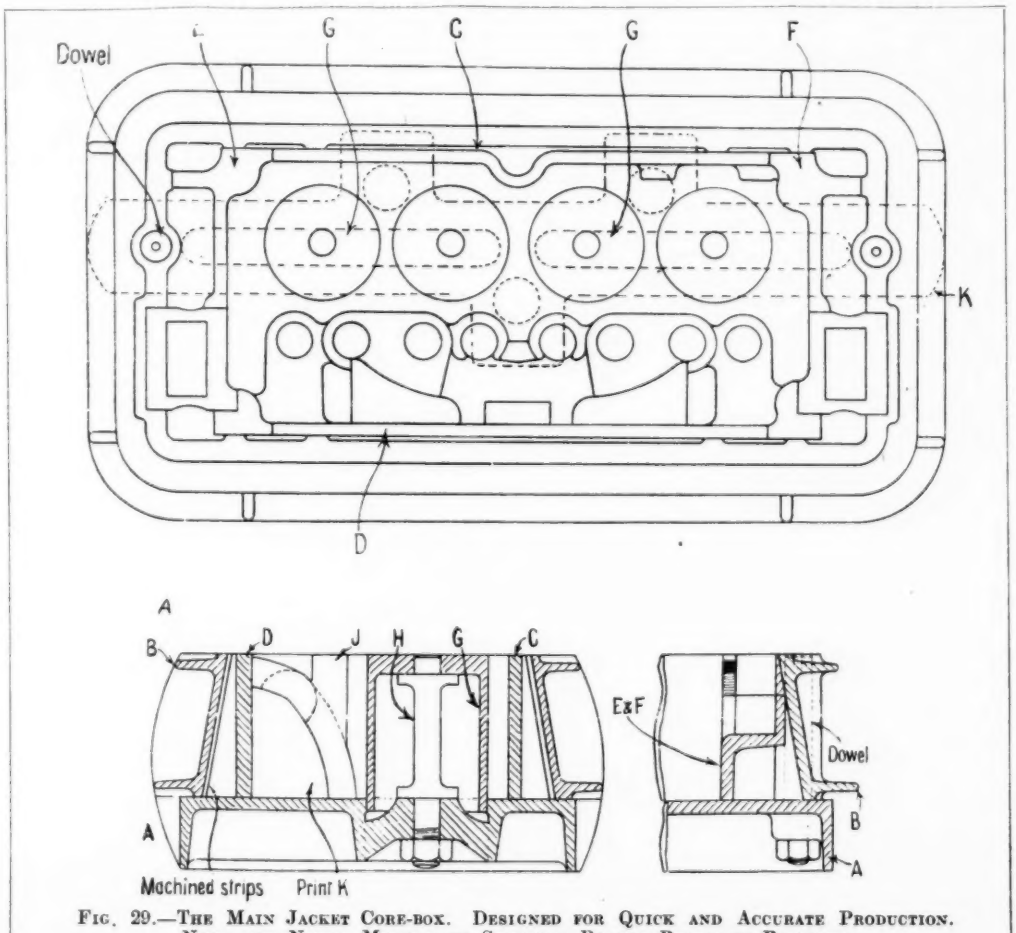


FIG. 29.—THE MAIN JACKET CORE-BOX. DESIGNED FOR QUICK AND ACCURATE PRODUCTION. NOTE THE NOVEL METHOD OF SECURING BARREL PIECES IN POSITION.

DISCUSSION.

In opening the discussion, MR. V. STOBIE remarked that he was very interested in what Mr. Molyneux had said concerning the material. Although he had said that the iron should be as hard as possible, bearing in mind, of course, the machining speed, the analysis which he had given did not strike one as being that of a hard iron. He had noticed in Fig. 14 a casting which had been made with some small jet runners. The top seemed to be a very large block of iron, if he had read the drawing correctly, which appeared to be out of proportion to the jets, which one would think would be chilled long before the top iron was fed.

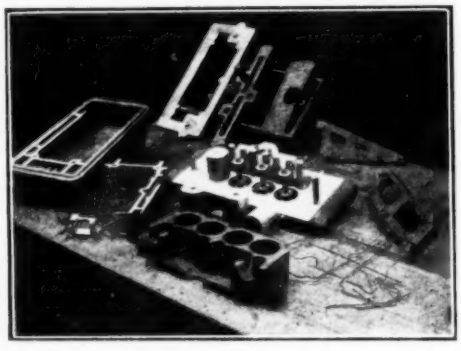


FIG. 30.—GROUP OF THE COMPONENT PARTS OF THE MAIN JACKET CORE-BOX, WITH CORE IN FOREGROUND AND BENDING BLOCKS FOR SOME OF THE CORE IRONS USED.

MR. W. J. PAULIN said that he had also been very interested in Fig. 14, which had shown a casting with a very heavy head and fine runners, which would involve a certain space of time to run. In the first place, there was the running period in which there was no question of rushing the metal, which must be run regularly and without displacing the design. After the metal had been run the casting itself began to consolidate and liquid metal to draw together. He wondered if the idea of milling the sand was to get the particles all the same diameter. If a container was filled with any particular size of sand, the relationship between the solid size and air spaces was exactly the same; but if different sizes of grain were put in the same container

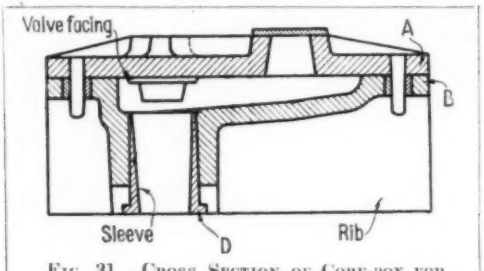


FIG. 31.—CROSS SECTION OF CORE-BOX FOR CYLINDER HEADS.

the relationship was at once disturbed. At the same time, it apparently made a much firmer core, and yet, if the theory were right, it ought to have been the opposite. In Fig. 6 was shown a heavy flywheel with "V"-shaped runners, and it was surprising how solid it looked. Was the same mixture of iron used for it? Mr. Molyneux had also referred to denseners made from cast iron. Did he make that iron of any special mixture to reduce gas? And had he ever experimented with wrought iron?

MR. H. J. YOUNG, F.I.C., observed that Mr. Molyneux had mentioned that he considered a pouring speed of 8 secs. per cwt. was a satisfactory one for small castings. He (Mr. Young) had seen ingot moulds in cast iron cast at the same speed take 5 to 10 minutes to pour. On the other hand, in marine foundries castings were actually poured at ½ sec. per cwt. He would like Mr. Molyneux to tell him, if he could, why these things were done. Mr. Young also asked if Mr. Molyneux really thought strainer cores strained the metal, and what he strained out of it. He was interested in what Mr. Molyneux had said about flywheels frequently being thrown out of balance after machining, and wished to know what was the reason for that.

MR. J. W. FRIER said that he would like to know the thickness of the cylinders, and allowance Mr. Molyneux gave for contraction, and the depth of chill and the effect of the chills, as he had been very interested in the method of chilling the bore of the cylinder. He had noticed that in the photograph of the pistons that they were run from the top, the runners being dropped into part of the dry sand core, and he wondered if there were any ill-effect.

MR. J. M. SMITH said that he would like to inform the meeting of a strange case, which might explain that question, in connection with a cylinder for a motor engine. The casting was

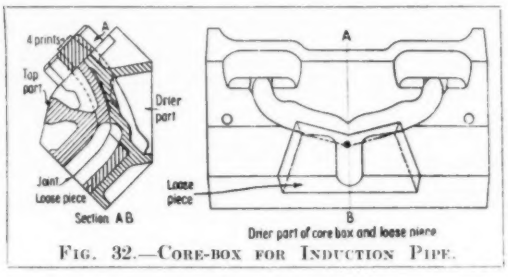


FIG. 32.—CORE-BOX FOR INDUCTION PIPE.

rejected because it was half an ounce too light. The drawn side could scarcely be seen, and yet that was the cause of the trouble. The work which they were discussing was so accurate that even a fraction of an ounce would reject the casting.

MR. H. C. JAY remarked that in making flywheels for fire engines, care had to be taken to get the flywheels perfect in form. Similar results had been obtained with a lower phosphorus mixture than that mentioned by Mr. Molyneux. For motor cylinders, phosphorus in the neighbourhood of 0.4-0.5 per cent. had been

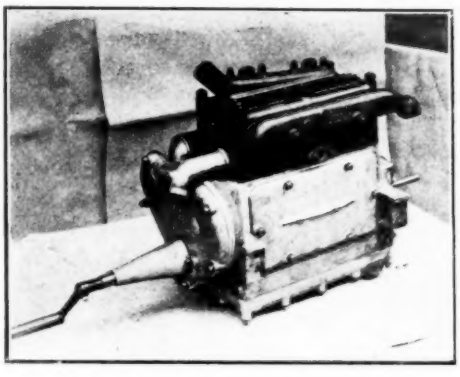


FIG. 33.—A FINISHED ENGINE.

very satisfactory, although on the Continent it was generally as high as 1.2 per cent.

MR. W. J. PAULIN remarked that this was unusually high. He also asked Mr. Molyneux if any trouble was experienced with the pistons which had extremely thin sections and yet two fine bosses.

In reply to the discussion, MR. MOLYNEUX said that, regarding Fig. 14, showing the half-time wheel, the method of running with small jet runners had nothing to do with attempting a draw. The real reason for their use was that, when castings of this type are made in thousands the moulder is apt to become careless, and, if they are not poured extremely hot, he does not get a complete casting, and, therefore, it is necessary for care to be taken. The grain size of the sand used in the little oiled cooled cylinder—*i.e.*, the one in which the sand was very hard—was very uniform, and the sand used was very dry. It was moulded on the jar ram machine, and could be rammed very hard, owing

to the small amount of moisture in the sea sand which was used and through very little gas being generated. That idea of jet runners had first been brought out by Ronceray, and had been found to be very satisfactory. A very suitable silica sand, which was finer than seashore, was Ryarsh sand, which was also suitable for cores such as piston cores, which must be very clean inside, no blacking being required with this sand. Referring to wrought iron, Mr. Molyneux said that he had never tried it, but that he had tried steel. For piston bosses, a mixture containing less than 0.4 or over 0.9 per cent. phosphorus gave sound castings, but in between these amounts there was a great tendency for porosity. The pouring rate of 8 secs. per cwt. had been taken from actual practice. It was simply a case of necessity, as the mould had to be filled quickly, although in different cylinder foundries there were differences of opinion as regards the speed of pouring; but he had found that a good working speed. Mr. Molyneux stated that he did not know exactly why the strainer cores were used, except that, as in the case of the jet runners, the man pouring with a pot ladle was forced to be careful, or else he did not get a casting, because by using a strainer core and covering it with paper the metal was retarded, and the moulder had to keep on pouring to fill the core. Great difficulty was often experienced in getting a flywheel in balance, and sometimes as many as six holes had to be bored to bring the flywheel into balance, owing to porosity. By using with strainer cores, however, very little balancing was required. They were first balanced on oak "V" blocks to try the rotary balance, and a fine degree of accuracy was necessary. The thickness of cylinder chills could only be discovered by experience. The cylinders were made in two half-round chills. Mr. Chapman raised the question of the thickness of the cylinder in Fig. 4. The boss was round, and occurred just in one place, and no difficulty whatever was experienced, the cylinder forming under $\frac{1}{8}$ in. Mr. Jay more or less confirmed what he himself had said concerning flywheels. In cylinder composition the standard practice in the U.S.A. was to have the phosphorus about 2 per cent.

In proposing a vote of thanks to Mr. Molyneux, MR. E. WOOD (President) said that he would like to mention that the subject of the grain size of sand was dealt with in a Paper which had been given by Mr. Herbst.

The vote of thanks was passed with acclamation.

Replying to the vote of thanks, MR. MOLYNEUX said that his only regret was that he had been able to cover so little of his subject in the short time at his disposal.

Foundry Query.

Vein Marks in Ingot Mould Castings.

With reference to your question respecting vein marks in ingot moulds I would suggest that the wrought-iron rings cause the marks. Seeing that something must be rammed up in the core to assist it to stand up, I should favour cast-iron rings with 9-in. prods. These would not cause a joint. A much cheaper and more perfect core could be bricked-up loam with a spindle and board. All that is needed is a bottom grid with two wrought-iron staples the length of the core cast in for lifting purposes, and two tieing grids, having 9-in. prods, one half-way and the other 12 in. from the top. Half a loam brick should be put in every core to allow for contracts, and care taken that an even thickness of loam (1 in.) is obtained. This core, I am sure, will have no veins.—LOAM.

New Secretary for the I.B.F. Lancashire Branch

At a meeting of the Council of the Lancashire Branch of the Institute of British Foundrymen on January 8 Mr. H. Stead was appointed Branch Secretary, to serve until the annual general meeting in April next. Mr. Stead will have the assistance of the present Assistant Secretary, Mr. C. F. Brereton.

Communications to the Lancashire Branch should be addressed to Mr. H. Stead, 1st. 36, Cheetham Hill Road, Stalybridge, near Manchester.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

A. M. Smith & Co., Ltd.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Referring to the paragraph we sent to your paper for publication, of which a copy is hereto annexed, an unfortunate mistake has been made in our publicity department. The gentleman who had charge of it did not understand the constitution of a limited company, and he did not realise, in framing the statement in question, that Messrs. Hilditch & Young therein mentioned were a firm of chartered accountants having charge of the affairs of A. M. Smith & Company, Limited. Messrs. Hilditch & Young are a firm of chartered accountants of highest standing in Liverpool, and whose financial stability is not only beyond question, but is in no wise involved in the acquisition by our firm of the plant of A. M. Smith & Company, Limited. You will understand that the misstatement is a matter of the greatest pain and regret to the directors of my company, and they desire that you should give the greatest possible publicity to this letter with a view to the mistake being as widely corrected as possible. It is desired that this letter shall carry with it an expression of regret by this company for the error and an earnest apology to Messrs. Hilditch & Young for the unfortunate imputation that has been made.—Yours, etc., THOS. W. WARD, LIMITED.

ASHLEY S. WARD,
Assistant Managing Director.

Albion Works, Savile Street, Sheffield.
January 14, 1927.

Primary Graphite in Cast Iron.

The form and size of the graphite lamellæ in cast iron are regarded as the principal factors which govern the mechanical properties of the iron. Thus, the large flakes of primary graphite are most detrimental to quality. B. Osann* is of opinion that though the precipitation of primary graphite is to be avoided because of the many hindrances thereby evolved in casting the iron, it is not justifiable to make the primary graphite responsible for the low mechanical properties. The real cause are the internal stresses generated by the quick cooling and the resulting undercooling. He tests his opinion by quoting some experiments he made some years ago with spiegel (10 to 12 per cent. Mn), basic pig, foundry pig. These irons, after being melted, were allowed to cool slowly by packing charcoal briquettes around the crucibles. After ten days the outer side of the furnace was still warm. The iron ingots showed such a high strength that only the spiegel ingot could be broken in a breaker. The analysis recorded in the following table showed that the top part of the ingots contained a higher carbon content than the bottom part. Though a great part of the precipitated graphite was primary graphite, the ingots showed the high strength mentioned above. This was due to the slow cooling rate which enabled the iron to reject the whole primary graphite; any under-cooling was avoided. The same is the case with the Lanz process, where, by preheating the moulds, the cooling rate is lowered.

	Spiegel.		Basic pig.		Foundry pig.	
	T.C.	Gr.	T.C.	Gr.	T.C.	Gr.
Initial comp.	4.6	0.12	—	—	4.28	—
End comp.—						
Top part ..	5.51	1.8	4.21	3.33	4.8	—
Bottom part	3.9	none	3.64	2.81	3.97	—

THE ADMINISTRATIVE COMMITTEE of the National Union of Manufacturers have passed a resolution of thanks to the Mining Association "for its courageous stand, in the face of a powerful and subversive conspiracy directed by Communist inspiration, for the determination of working conditions and wages by economic forces and for refusing to give way to a popular but mistaken outcry on the part of politicians and political philanthropists, whose short-sighted attempts at mediation only resulted in strengthening the very forces which they sought to placate."

* "Stahl und Eisen," 1926, No. 39, p. 1320-4.

Light Aluminium Copper Alloys.

By "CELSIAN."

Considerable divergence of opinion exists with regard to the best method adopted and the proper proportion of components employed in the manufacture of light aluminium copper alloys for various purposes. Copper and aluminium alloy in all proportions but certain percentages of these metals combine better than others.

It frequently happens, however, that an alloy of good composition is rendered practically worthless on account of careless treatment, either in melting or mixing. On the other hand, an alloy of inferior composition, properly worked, can be made to produce comparatively homogeneous metal. Disappointing results exhibited by certain metals are more frequently due to inexperienced melting and mixing than to inferiority of composition.

Proportions.

The alloy most commonly used for general sand cast productions is one containing approximately 92.0 per cent. aluminium and 8.0 per cent. copper. Other alloys employed for commercial castings contain from 12.0 per cent. to 14.0 per cent. copper and the remainder aluminium. For sand cast cooking utensils and such like an alloy containing 96.0 aluminium and 4.0 per cent. copper is considered most satisfactory. Castings of about 9.5 to 1.5 per cent. copper and the balance aluminium are used for automatic castings, such as pistons, etc. Alloys of from 4 to 12 per cent. copper are employed only for special purposes. Under the name of aluminium bronze containing 90 per cent. copper and 10 per cent. aluminium, the alloy is largely employed for optical instruments, armour plate, propellers, etc., but aluminium bronzes are not referred to in this article.

The proportion of aluminium alloys in demand for other castings, such as aluminium-magnesium, aluminium-zinc, aluminium-copper-tin, or aluminium-copper-manganese, is small compared with that for castings of 92 per cent. aluminium and 8 per cent. copper alloy.

Methods.

There are several methods of making up 92:8 aluminium-copper alloy in foundries for casting purposes, and a variety of materials may be employed in the melting charge. Existing conditions, material available, market prices, etc., largely influence founders in the choice of a method for the production of 92:8 aluminium-copper alloy. From the metallurgical standpoint, however, the principal consideration is the method adopted for introducing the copper. This is a peculiarly important matter in foundry practice, because, whichever method is selected for making the alloy, controls dross losses, oxidation, shrinkage and casting losses, as well as expenditure.

Casting ingots of 92:8 aluminium alloy are marketed, made directly from virgin metals. Secondary ingots are run down by smelters and refiners from aluminium alloys, borings and turnings, scrap castings, aluminium clippings, etc.

Some founders prefer to manufacture light aluminium-copper alloys by the addition of solid copper to liquid aluminium. Although customary in small shops, this method is not greatly favoured where large plant is in operation.

When copper is introduced, the customary practice is to melt the aluminium first, adding the necessary proportion of copper afterwards. For instance, for a small heat of the 92:8 alloy of 100 lbs., 92 lbs. of aluminium would first be liquefied in a crucible, after which 8 lbs. of sheet copper would be introduced. Sheet copper goes into solution in aluminium quickly at 700 deg. C., which is well under normal furnace temperature in aluminium melting practice. Alloying takes place partly by diffusion and partly by solution.

As a general rule copper is introduced in the form of clean, light gauge sheets, clippings and punchings, light sheet scrap or scrap wire. This metal is very seldom used in the form of ingots, because the period occupied in reducing pieces of large dimensions to solution is lengthy and possibly unprofitable. The use of copper added directly in making 92:8 alloy is, in some foundries, considered more economical, as it alloys successfully and eliminates the cost of preparing rich alloys, such as 33:67 and 50:50 copper-aluminium. The 33:67 alloy is not employed so frequently in foundries as pure copper or the 50:50 copper-aluminium. Segregation does not occur within itself in 33:67 as it does in the 50:50 alloy, the low melting point of the former, 540 deg. C., being considered a recommendation by some founders for facilitating the introduction of copper. When placed in liquid aluminium, the 33:67 alloys rapidly, melting almost immediately.

When an eutectic alloy freezes, the crystallisation of both components occurs at the same time, and thus forms a very intimate compound. Although such an alloy cannot be, correctly speaking, homogeneous, it may sufficiently resemble that condition to be considered such.

When 33:67 alloy is charged solid together with solid aluminium, it will melt first, but some diffusion of the solid aluminium into the liquid alloy will occur before the former melts. A 33:67 copper-aluminium alloy, aluminium ingot and foundry scrap are charged in correct percentages so as to produce a 92:8 alloy, and the relative proportions of the different materials in a charge may vary considerably.

The 50:50 copper-aluminium alloy is an old favourite for introducing copper into aluminium, since it readily alloys, melting at 575 deg. C., a lower temperature than aluminium. Unless the 50:50 alloy is thoroughly stirred it is liable to segregate badly and requires to be rapidly frozen by casting into chill moulds. If segregation occurs, lack of uniformity may take place in successive heats of 92:8 aluminium-copper, but as a rule no trouble should arise from this source. When using 50:50 copper aluminium, the charge is made up of the necessary proportions of that alloy, aluminium ingot and 92:8 aluminium-copper scrap.

Defects.

Objections are sometimes raised that the use of copper direct in making up 92:8 alloy is the cause of heats running "hard" and "soft" on account of insufficient stirring. If castings of uniform composition are to be produced even with the use of rich alloys, thorough stirring and mixing are indispensable. Running hard and soft may be the result of improper agitation during melting, but may be caused by other troubles.

Whilst certain founders complain of lack of uniformity in productions owing to their running hard and soft, others experience difficulty with porosity and excessive shrinkage in castings made with copper direct.

Light copper in the form of borings, clippings, etc., is appreciated more than heavier forms of the metal, because it speedily goes into solution in the liquid aluminium well under normal furnace temperature in aluminium practice. When heavy, unwieldy copper is introduced, high temperature is necessary, which acts deleteriously on aluminium alloys, resulting in porous and unsound castings, through the absorption of gases and oxidation of the alloy. In foundry practice the temperature should be approximately 752 deg. C. If trouble is experienced when castings require to be poured at higher temperatures on account of difficulty in running them, the furnace charges would necessarily be raised to 810 to 845 deg. C. Provided small and light pieces are introduced, solid copper alloys with aluminium at both high and low temperatures. If copper is greasy, or even dirty, boiling in sodium hydroxide is recommended. To subject the metal to this treatment when neither greasy nor dirty, but in order to secure a bright surface, only adds needlessly to the cost of production. Use should never be made of badly oxidised copper, since an increase in dross losses would be experienced.

As far as the quality of light aluminium-copper castings is concerned, the various methods adopted should prove equally good, provided thorough alloying is accomplished.

Whether castings are made from new metal or scrap alone, or from a mixture of both, the advantages and disadvantages accruing therefrom equalise so well that there is little choice between them on the score of economical productions.

Simplifying Foundry Work.*

By Arthur Logan.

The Principles of Moulding.

The object of the Paper is to convey as simply as possible some of the principles which come into operation during the production of a casting. Every piece of machinery is built up of castings of one kind or another—the foundry is, in fact, the very foundation of all engineering. It is surprising, therefore, that foundry research and improvement have been almost entirely neglected until quite recent years.

With ordinary moulding, patterns in wood which conform to the outside contours and formation of the casting are used as models. As is well known, these patterns are not the exact size which the finished casting must be, but every dimension is increased by a certain definite ratio, varying according to the material with which the mould is to be cast. This is the contraction or shrinkage allowance, and is necessary owing to the fact that the mould is filled with metal at a high temperature, and therefore considerably expanded. On solidification, and cooling down to atmospheric temperature, both liquid and solid contraction occur, and the casting decreases in size. This decrease is not necessarily uniform with unit drop of temperature, as complex material such as cast iron has actual expansions at two or three points whilst cooling. The liquid contraction may also be greater than the solid contraction. The general net result, however, with the majority of commercial alloys is a contraction. Normal contraction allowances of some commonly used materials are as follows:—

	Small Castings.	Large Castings.
Steel	From $\frac{1}{4}$ in. to $\frac{3}{16}$ in. per ft.	
Cast iron	From $\frac{3}{32}$ in. to $\frac{1}{16}$ in. per ft.	
Non-ferrous alloys generally	From $\frac{5}{32}$ in. to $\frac{1}{8}$ in. per ft.	

The lecturer then gave a simple description of practical moulding, finally stating that the following are some of the points which have to be prearranged before a successful casting can result: (1) A correct sand mixture for the particular purpose; (2) a perfect mould shape with correct dimensions, cores in correct positions to give accurate thicknesses of metal; (3) all cores, thin portions, or loose pieces of sand carefully fixed in position to prevent disturbance due to movement or wash of metal during casting; (4) perfect venting in green-sand work to carry off all gas generated during casting; (5) correct gating and running, *i.e.*, the runner or runners to be in the best position on the casting, and the gate size to be correct to give the right rate of filling the mould; (6) to arrange for "feeding" where necessary; (7) to arrange that the rate of cooling is as uniform as possible, and that solidification is progressive throughout the casting; and (8) to arrange as far as possible the correct rate of cooling, *i.e.*, some alloys require rapid cooling, and some slow cooling.

Principles of Solidification and Equilibrium Diagrams.

Having briefly sketched the process necessary to form the mould, the lecturer considered what happened when the mould is filled with molten metal. Amongst other things, it was desirable to consult the equilibrium diagram of the particular alloy dealt with. Most alloys used in non-ferrous work are some compcsition of brass or bronze, generally with further additions of other metals; but the equilibrium diagrams of the copper-zinc and copper-tin series will give an approximate idea of what happens on solidification. Fig. 1 shows the equilibrium diagram of the copper-zinc series, and Fig. 2 shows the copper-tin series. It should be noted that these equilibrium diagrams as shown are not definitely accurate, as these systems have not been finally investigated and definite diagrams universally agreed upon. New investigations are constantly adding to our knowledge and introducing modifications: but in general, they indicate the process of solidification sufficiently accurately for the present purpose.

Take, for example, a brass of the Muntz metal type—60 per cent. copper and 40 per cent. zinc. Copper has a freezing point of 1,084 deg. C. and zinc 419 deg. C., so that, as can be expected, additions of zinc very quickly lower the freezing

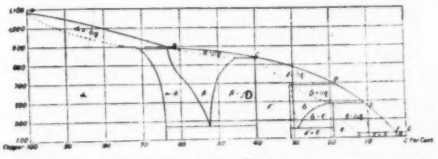
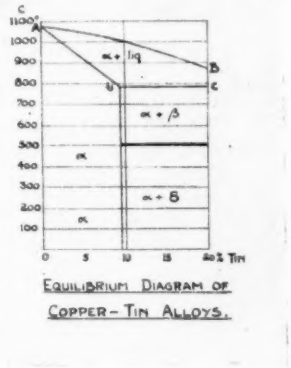


FIG. 1.—EQUILIBRIUM DIAGRAM OF THE CU : ZN ALLOYS.

points of the resulting alloys. The line ABCDEFG in Fig. 1 is shown as the liquidus, as above this any alloy of copper and zinc is completely liquid and in perfect solution. The dotted line indicates the completion of solidification, and below this all alloys are solid. Alloys containing up to 37 per cent. zinc, when fairly slowly cooled, exist as crystals of a single solid solution of zinc in copper known as the alpha solid solution. Between 37 zinc and approximately 46 per cent. zinc a second solid solution—beta—makes its appearance, and the alloy consists of a mixture of the alpha and beta solid solutions. Between 46 and 49 per cent. zinc the



EQUILIBRIUM DIAGRAM OF COPPER-TIN ALLOYS.

FIG. 2.—EQUILIBRIUM DIAGRAM OF THE CU : SN ALLOYS.

structure consists of the beta constituent entirely, and beyond 49 per cent. zinc the alloys are useless, on account of extreme brittleness due to the appearance of another constituent known as gamma.

An alloy of 40 per cent. zinc commences to solidify at approximately 880 deg. C. The structure of the material first solidifying is the beta constituent. Solidification is rapidly affected, there being only a very short freezing range of about 20 deg. C. The structure, when completely solid, consists of the beta constituent, but after the alloy has cooled down below 800 deg. C., the alpha constituent commences to form from the beta, and if the rate of cooling is fairly slow, the alloy will consist of approximately equal amounts of the alpha and beta solid solutions when finally cold.

Bronzes.

Again, as copper has a freezing point of 1.084 deg. C., and tin 232 deg. C., no mixture of copper and tin can have a freezing point as high as that of pure copper. A big difference will be noticed, as the bronzes have a greatly extended freezing range. (In the case of 60/40 brass, the liquidus range was only a matter of 20 deg.; but

* An abridgment of a Paper given before the local section (North East Coast) of the Institute of Metals.

here, in the case of a 10 per cent. bronze, for example, the range is approximately 200 deg. C. from approximately 1,000 to 800 deg. C. This is very important from the foundry point of view.) The material solidifying first is almost pure copper, consequently the remaining liquid becomes richer in tin. As solidification proceeds, the amount of tin in the solidifying portion increases, until at about 800 deg. C. the alpha solid-solution contains somewhere about 9 per cent. At this temperature the remaining tin-rich liquid now solidifies and forms the beta solid-solution, which, at 500 deg. C., is unstable, and breaks down into alpha and another constituent known as delta. The final structure, therefore, consists of a matrix of unhomogeneous alpha, in which occur varying amounts of the alpha-delta eutectoid. In actual practice, the rate of cooling is of the very greatest importance, especially during the critical

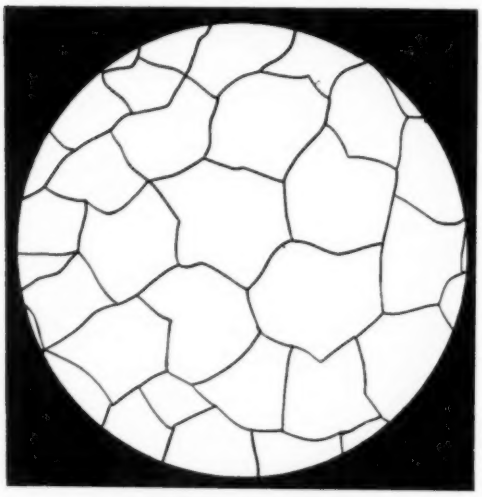


FIG. 3.—NORMAL APPEARANCE OF A PURE METAL UNDER THE MICROSCOPE.

period of solidification, for it practically determines the structure, and, consequently, the physical properties which the finished casting will possess.

Crystallisation.

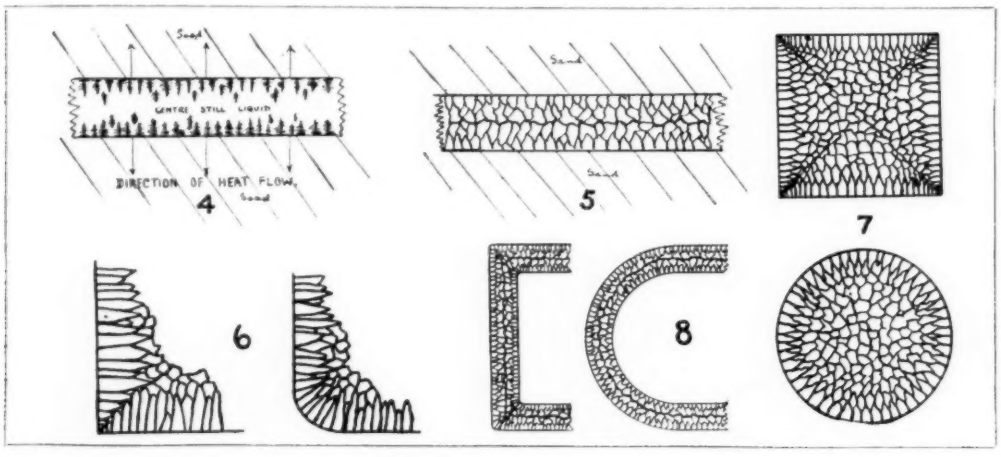
All metals and alloys are crystalline, and the formation of the crystals is interesting, and also of importance, for their size and arrangement influence the physical properties of the casting. Pure metals exhibit a definitely uniform structure, showing only the crystal boundaries under the microscope. Fig. 3 shows the crystal boundaries of a pure metal as seen under the microscope. Most alloys, when fairly rapidly cooled, show more or less a dendritic structure—depending upon the extent of the freezing range of the particular alloy, and the time taken to pass through the solidification range. The bronzes provide a good illustration of this. Taking a 10 per cent. bronze, solidification commences at all parts of the mould which have cooled to approximately 1,000 deg. C. This will naturally be at the spot farthest away from where the metal was admitted to the mould, and will commence at the wall of the mould. Dendrites of almost pure copper commence to solidify at right angles to the cooling surface. This is indicated in Fig. 4, which is an attempt to convey an idea of what is taking place, but which, of course, must not be taken too literally. Further dendrites continue to grow in towards the centre of the section. Branches, or arms, in the form of secondary dendrites, grow out at right angles to the main axes, and the structure is gradually built up—the material deposited round the centre dendritic skeleton of almost pure copper becoming richer and richer in tin. The actual shapes of the crystals are quite haphazard, and are entirely due to the interference of one with another. Fig. 5 shows the completion of solidification.

When fractured, many metals and alloys show their crytalline structures quite well. Good gunmetal, broken hot, shows an intercrystalline fracture, and is a rough foundry test for the quality of gunmetal scrap.

Effect of Design upon Crystallisation.

Remembering that the crystallisation commences from the wall of the casting, and proceeds inwards, it will be seen that the actual shape of the casting will have quite an influence on the strength, apart from anything else. In the case of the square corner illustrated in Fig. 6, it will be seen that there is a distinct line of weakness set up in a sharp angle of this kind. The weakness is not only due to the irregular crystallisation, but also to the fact that those portions of the alloy last to solidify will accumulate at this junction. In the case of the bronzes, for instance, more of the brittle tin-rich constituent will be found at such a place. If the alloy contains much lead, it will also tend to segregate here. Dirt and slag, etc., are also prone to be left behind and greatly increase the weakness and chance of failure. The remedy is obviously to do away with all sharp corners and angles—hence the necessity for fillets on all castings. The influence of mould section and shape on crystallisation is indicated in Figs. 7 and 8.

A form of design which is responsible for trouble in the foundry is the use of very unequal sections in immediate proximity. It is bad design, for instance, to have a section of 2 in. tacked immediately on to a casting where the general thickness is only a matter of ½ in. or ¾ in. thick. The trouble is not so much a matter



of crystallisation as of contraction stresses set up due to unequal cooling and solidification. In the first place, the thin portion, whilst solidifying, will draw metal away from the thick portion to make good the liquid contraction which is occurring, and, unless the thick portion is in turn "fed" with still liquid metal, a shrinkage hole or cavity in the form of a "draw" or "pipe" will result. Not only this, but the thin portion, with its more rapid cooling, will solidify first, and its further contraction will exert a strain on where it joins the thick portion. There

is then the risk that a crack will develop in this junction, or that the casting will warp. If the metal does stand the strain without tearing or warping in the mould, the resulting casting will still be in a state of internal strain. Another aspect of bad design leads to a consideration of casting temperature.

Effect of Casting Temperature on Crystallisation and Solidification.

In cases of extreme sections, the casting temperature which will be correct for one section will be incorrect for the other. The foundryman, for instance, will have to arrange his casting temperature to suit the thin section, so that there is no chance of the casting being mis-run. This means that the high temperature necessary for the thin section will be too high for the thick section, with its greater mass and slower cooling. The result of this is that the thick section will have coarse crystals and poor structure generally; and, with some alloys, strong possibilities of segregation. As far as actual crystal or grain size is concerned, the hotter the metal is cast, the larger the actual crystals formed. This is really equivalent to saying that the slower the cooling the larger the grain size; for the greater the superheat given the metal when casting, the greater the walls of the mould are heated, and consequently the slower the cooling.

Generally, the smaller the grain size, other things being equal, the greater the strength. Arguing from this, one might say that the lower the casting temperature the stronger the resulting casting, but this cannot be laid down definitely as a fixed principle, as other factors have to be taken into account. As a generalisation, however, especially as regards the bronzes and phosphor-bronzes, it is correct.

It is interesting to note that sometimes metals are added to certain compositions for the purpose of inducing smaller crystallisation. In the case of the high-tensile brasses, the conditions which give the best structure and physical properties are those of very slow cooling, almost amounting to an annealing whilst in the mould. Unless means were taken to avoid it, therefore, these conditions would also produce very large crystals which would tend to neutralise the strength and good properties desired. This difficulty is surmounted by the inclusion of about 1 per cent. iron in the composition. This iron forms small complex iron-rich particles of high melting point, which are distributed throughout the alloy, and which act as innumerable nuclei and promote crystallisation from a large number of centres, with the result that the initial grain size is rendered very much smaller. The subsequent grain growth on slow cooling therefore does not cause the crystal size to be unduly large.

The original grain size of alloys can be readily changed by heat treatment or work. This is not so important with non-ferrous alloys as it is with steels, as incorrect heat treatment may leave a piece of steel with large, coarse crystals, which are subsequently discovered when fracture takes place. High-tensile brass is subject to rapid grain growth at temperatures over 700 deg. C.

Structures of Industrial Alloys.

As stated previously, the majority of industrial non-ferrous alloys are brasses or bronzes adapted to the particular need by regulation of the composition. Intelligent alteration of composition can only be usefully accomplished when the structure is known and understood, and the alteration thought of in terms of the resulting modification to the structure.

The commonly used compositions, such as 70/30 and 60/40 brass, 87 Cu:8 Sn:5 Zn; 88 Cu:10 Sn:2 Zn; 85 Cu:15 Sn, etc., were probably developed in the first place as a result of practical experience, but they are suitable for their respective purposes because their structures give them the necessary physical properties. Every commonly used composition has what may be termed its own ideal structure, which will be found in material of that composition when every stage of the manufacture has been carefully carried out under exactly the right conditions. The suitability of any piece of metal can then be judged in so far as its structure approximates to the ideal. Here then is the reason and necessity for the great care which has to be taken in the foundry, especially with all non-ferrous alloys. Unless the greatest care is taken during the making and melting, and the mould poured at the correct casting temperature, the structure of the material forming the casting will be affected and good results rendered impossible. Not only the structure of the material will suffer, but physical defects, such as unsoundness, blowholes, shrinkage cavities, etc., will possibly also be found and add to the general detriment of the casting.

Admiralty gunmetal (88:10:2) is widely used, as it is suitable for general constructional purposes, pressure work, and, in a lesser degree, for bearings also. The conditions which produce the soundest and strongest material are those of careful melting, casting from the correct casting temperature, and rapid solidification, with slow after-cooling if possible. These conditions result in a strongly dendritic structure, and this structure always denotes strength in a casting of this composition. The reason for the rapid solidification is to prevent the formation of much of the tin-rich liquid which forms the beta constituent, or as it exists later in the casting, the alpha-delta eutectoid. It follows therefore that strong gunmetal, with its rapidly solidified dendritic structure, contains very little of this alpha-delta eutectoid. The opposite extreme is found in poorly melted and incorrectly cast material. This gives a weak, loose arrangement which is often actually porous. Evidence of too high a casting temperature or too slow cooling is found in the large quantity of the hard, brittle alpha-delta eutectoid which is present. This delta eutectoid is not without its uses, however, for its presence is purposely sought in bearing metals where hardness and wearing qualities are desired. As it is composed of copper and tin, it follows that the addition of more tin will produce it in greater quantity even when rapidly cooled, as it should be, consequently such compositions as 85 Cu: 15 Sn; 84 Cu:15 Sn:1 Pb; or 85 Cu:14.5 Sn: 0.5 P, are found to be used for bearing purposes.

Brasses.

The structure of 70/30 brass being composed entirely of the alpha solid solution of zinc in copper (which, from the equilibrium diagram, consists of copper containing up to 37 per cent. zinc, and having only a short solidification range) does not exhibit such a strongly dendritic structure as does gunmetal, and slow cooling or slight annealing renders it homogeneous.

The high-tensile or manganese brasses are a good example of the effect which changes of composition and their corresponding changes of structure have upon the physical properties.

Effects of Changes of Composition.

Very briefly, the usual additions which are made, such as tin, manganese, aluminium, etc., do not form separate constituents in the alloy, but act as further additions of zinc, but with increase of strength, each metal having its own coefficient of equivalence. The addition of any one of these metals therefore is equivalent to adding a further definite amount of zinc, and the result is the formation of more beta in the structure with its consequent increase of tensile and reduction of elongation. An alloy, for instance, of 58.27 per cent. copper, 1.17 per cent. tin, 0.05 per cent. lead, 0.89 per cent. iron, 0.61 per cent. manganese, 0.20 per cent aluminium, and 38.81 per cent. zinc, etc., has a zinc equivalent or zinc value of approximately 42.7 per cent. An ordinary brass containing 38.8 per cent. zinc has a structure consisting of approximately 80 per cent. alpha and 20 per cent. beta, but this manganese brass has a structure of approximately 40 per cent. alpha and 60 per cent. beta, due to its fictitious zinc content.

Practical Considerations.

Before a perfect casting can be produced there are a number of essentials which must be correct. The more important of these in their correct order are:—(1) That the design or shape of the casting must be suitable, *i.e.*, it should not have any sharp angles or very unequal sections immediately adjacent; (2) the sand of the mould must be in the correct condition. This embraces a large number of subsidiary conditions, the more important

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being that it must be the right kind of sand, the sand must have the right degree of ramming, it must be of even moistness, and well vented if to be cast green, and perfectly dried if to be cast dry; (3) the mould shape must be correct, and a true replica of the pattern or drawing; (4) the alloy must be correctly made, and of the right composition and free from oxidation; (5) the casting must be run from the right position, and at the right rate.

(6) Mechanically mixed impurities must be avoided. Slag, sand, dirt, etc., must be carefully skimmed off, and prevented from entering the pouring basin. All loose sand must be removed from the mould, runners, and pouring basin. Avoidance of mould surface scabbing by attention to previously mentioned conditions. (7) The casting must be poured at the correct casting temperature. This depends upon the section and size of the mould in conjunction with the range of correct casting temperature of the particular alloy used. For example, Admiralty gunmetal has a range of from 1,100 deg. C. to 1,220 deg. C. Light sectioned small castings would therefore be cast at the upper end of the scale, whereas large heavy castings would be cast at the lower end of the scale. The exact casting temperature would be a matter which would be decided by the section and mass and the distance the metal had to flow to fill the mould.

Other alloys have their own range of casting temperature, generally not so extensive as that of Admiralty gunmetal. Manganese brass, for example, has a very limited casting range, compositions similar to that given being approximately 1,000 deg. ± 20 deg. C.

In a broad sense, there are three departments concerned with the production of sound castings which will be suitable for their purpose:—There is the designer or draughtsman who fixes the shape of the casting; there is the foundryman or moulder who prepares and fills the mould from the pattern; and, finally, the metallurgist, who may control or advise as to the most suitable alloy to fit any particular purpose. It is only by collaboration of all three that successful castings can be produced.

The Use of Fluorspar in Cupola Practice.

L. Zerzog* made investigations in order to determine the influence of fluorspar on the melting process, especially on the desulphurisation. The results of the experiments are recorded in the above table. The iron charge was 200 kg. The analysis of the molten iron calculated from the mixture was to be 2.12 per cent. Si, 0.80 per cent. Mn, 0.08 per cent. S. The composition of the limestone was 2.15 SiO_2, 0.17 Al_2O_3, 53.1 CaO, 0.9 MgO, and 42.2 per cent. loss on heating. The fluorspar contained 83.45 per cent. $CaFl_2$. The analysis of the refractory lining was 88.12 SiO_2, 4.35 Al_2O_3, 1.07 Fe_2O_3, 0.09 CaO, and 0.09 per cent. MgO. The analysis of the coke ash (9.12 per cent.) was 35.25 SiO_2, 29.31 Al_2O_3, 1.63 MgO, 10.02 Fe_2O_3, and 8.39 per cent. CaO. In Experiment 4 another coke was used with 12.76 per cent. of ash, the composition of which was 33.8 SiO_2, 22.54 Al_2O_3, 12.26 Fe_2O_3, 7.82 CaO, and 3.15 per cent. MgO. On these experiments the following notes have to be made:—

Experiment 1.—The tuyeres had to be freed from slag for several times. The slag contained iron shots, the amount of which was 2.15 g. per cm^2 of slag. In the receiver there were heavy accumulations of slag, coke residues and burned limestone.

Experiment 2.—By the forced working, the loss of silicon and manganese as well as the gain of sulphur is greater than in Experiment 1, though more limestone was added. The FeO content of the slag has been definitely raised. The tuyeres were free from slag. There was no iron shot in the slag. The lining was normal.

Experiment 3.—There was no iron shot in the slag. The lining was glazed.

Experiment 4.—The result is similar to that of Experiment 3. The larger quantity of slag may be caused by the higher Fe_2O_3 content of the coke.

The experiments show that the fluorspar only brings about an indirect desulphurisation so far as the SO_2 gas can easily escape through the thinly liquid slag. This slag hinders also the formation of iron shot. As to the quantity of limestone and fluorspar to be added, a good ratio may be 2 to 1. But it is better to calculate the amount of fluorspar according to the viscosity of the slag which will allow the formation of threads. Too large a quantity of fluorspar ruins the lining. As to the noxious influence of the gases on vegetation which is often quoted, the author found that such an influence does not exist.

Melt No.	1	2	3	4
Coke charge in per cent. of the iron charge ..	10	12	10	10
Limestone charge in per cent. of the coke charge	30	35	20	20
Fluorspar charge in per cent. of the coke charge	—	—	10	10
Composition of the molten iron:				
Si	1.86	1.72	1.92	1.89
Mn	0.68	0.62	0.72	0.74
S	0.118	0.124	0.10	0.10
Temperature of the iron, C.	1,220	1,310	1,300	—
Temperature of the slag, C.	1,190	1,240	1,280	—
Volume of blast, m^3/hour	25	31	25	—
Pressure of blast, mm. H_2O	300	370	300	—
Colour of the slag	Dark green	Dark	Green	—
Viscosity of the slag	Liquid, rapidly freezes	Threads	Thinly liquid	—
Amount of slag, in per cent. of the total charge	7.12	8.94	7.15	8.25
Composition of the slag:				
SiO_2	51.32	53.32	49.25	—
Al_2O_3	10.74	17.42	12.95	—
CaO+MgO	25.26	26.34	26.37	—
FeO	8.12	11.54	4.94	—
$CaFl_2$	—	—	0.96	5.96

Other experiments showed that, when using fluorspar, the desulphurisation is raised by 15 to 25 per cent. The slags, the composition of which are given below, were very much thinly liquid.

	1	2	3
	Per cent.	Per cent.	Per cent.
SiO_2	46.4	47.4	47.0
Al_2O_3 ..	19.9	10.8	22.0
CaO	19.6	29.9	25.0
FeO	5.0	1.5	2.0

* "Giesserei-Zeitung," 1926, No. 18, 19.

Continental Steel Trust.—Various reports have been current with regard to the participation of British iron and steel producers in the Continental Steel Trust. Whilst it is perfectly true that the possibilities of British participation are being explored, no new development has taken place since the last meeting held about a month ago, when the matter was under consideration, but no basis of negotiation was established, as no agreement was reached on the amount of the British quota. We understand that until the next meeting of the Trust, to be held early in February, no further information as to progress toward finality is possible, and that reports to the contrary may be discredited.

Nickel and Nickel-Chromium Cast Iron As Now Used in America.

By T. Henry Turner, M.Sc. (Lecturer in Metallurgy, University of Birmingham).

Introduction.

Cast iron is frequently regarded as only a crude material, in an entirely different class from other metals. Brazen gates, golden goblets and Damascene steel have poetic appeal to all, whereas only the foundryman appears to get a thrill out of cast iron. He knows that it is a marvellous material and that it plays an important part in the world's work, and that despite the invention of new alloys and the commercial production of more and more types of metallic materials, cast iron is to-day produced in greater tonnages than ever. Cheap steel, drop stampings, hot pressings, die castings in non-ferrous metals, lattice-work construction, etc., have surely threatened to replace cast iron, and it is true that the cast-iron parts of the old beam engines have been replaced by forgings in the modern high-speed machines. It is equally true, perhaps, that centrifugal cast-iron pipe-lines will replace many lines of corroded mild-steel pipe. The amount of cast iron used is still an indication of a nation's prosperity, but the continued production of large tonnages has only been achieved by constant adaptation to new circumstances, improvement in plant and practice, and standardisation of quality by careful control. The development of the drop stamp has been balanced by the introduction of the moulding machine, mass production has been answered by mass production, rolling to shape finds a competitor in centrifugal casting, and die-casting is answered by permanent moulds for cast iron.

What is the Cast-Iron Industry Doing to Keep its Place in the Alloy Steel Era?

The author has an inherited interest in cast iron, for his father (Professor Turner) carried out some of the early pioneer research work which has undoubtedly aided many foundrymen; so that when he recently had the pleasure of visiting privately some twenty or more foundries in the Eastern States of America, he asked what effect the alloying or improvement in chemical technique of steels had upon cast irons. Several somewhat sketchy or pedagogic lectures which he had previously heard, upon the effects of adding various elements to cast iron, had not impressed him, because alloying is inevitably costly and castings are not used where maximum strength is required. They are used, however, where the shape is difficult to produce by forging and machining, or where friction is present, or the stress is very steady or cheapness is essential. These latter considerations make one realise that *there is a big future for improved or alloyed cast iron; indeed, its use is inevitable.*

Turning aside for the moment to the alloy steels, one gets the impression that most of the alloying materials (Va, W, Co, Mo, Mn, Ni, Cr, Ti, Cu, Si etc.) are used in comparatively small quantity, but there can be no doubt that nickel, chromium, silicon and manganese enter into large tonnage production.

These are the elements which may be expected, therefore, to enter largely into the cast iron of the future. The author's present interest is mainly directed to nickel and chromium, for the effects of silicon and manganese have been studied many years ago.

The following is, therefore, a consideration of observations relative to the use of nickel and nickel-chromium cast irons in the American plants which he recently visited. It should be clearly understood that, in nearly all the cases mentioned, the addition of the nickel and chromium *has only been made after testing out the usual variables in the foundry mixture.* Nowadays steel additions are so common that the term "semi-steel" has become obsolete. Nearly all foundries make an addition of steel scrap to their charge. Furthermore, there can be no doubt that the recent indications of a definite return to popularity of cast iron in certain quarters, have been due to intensive study and experimentation along many lines.

In the cast-iron cylinder block foundry of the Cadillac Motor Works, Detroit, it was stated that the revolving automatic sand slinger which was then being used there, was the greatest development introduced into the foundry in recent times.

Improvements of all kinds in foundry lay-out, equipment, moulding, pouring practice, supervision and operation of the cupola, reverberatory or mixer, and finally in means whereby alloying materials may be added, have all contributed to the present undoubted success of the American foundry industry.

Influence of Ni and of Ni-Cr Additions to Cast Iron.

It has been said that experience in this country with regard to nickel additions to cast iron does not coincide with accounts received from the States. Research work has, therefore, been commenced in the Metallurgical Department of the University of Birmingham, England, with the object of confirming, if possible, the work of T. H. Wickenden and J. S. Vanick. In the meantime, those seeking an account of careful systematic research work upon nickel and chromium additions to cast iron, should turn to a Paper read by those two workers before the American Foundrymen's Association, in the latter part of 1925. A large number of original tests are there described, and the publication of their work was very well received. The discussion of the Paper showed that many American metallurgists were in substantial agreement with their findings, and welcomed the Paper as one that would "show the practical foundryman that nickel has a decidedly beneficial influence upon the structural conditions of the grey iron casting if judiciously added, and their work is of such extensive and voluminous character that little can be added"—to quote some of the remarks made by W. J. Merton, of the Westinghouse Works, in Pittsburgh, Pa.

Besides reporting the results of their laboratory and foundry tests, these authors discuss the commercial applications of cast irons containing nickel and nickel-chromium. It is not proposed to refer to their statements in this connection, other than to say that the earlier remarks upon the extent to which these alloy cast irons are being used covered practically the same ground. Indeed, the author had the pleasure of visiting some half dozen or more foundries in the company of Mr. Wickenden, and was thus able to find confirmation of what the latter had written last year.

Another most interesting Paper has been published by the Chicago Crucible Company, in the interest of better castings, written by J. Trantin, Jr., Met. E., Director of Research, Pettibone Mulliken Company, Chicago. The latter summarises the *results of adding nickel* to a 2.50 per cent. silicon base cast iron as follows:—

"(1) By virtue of its peculiar property of reducing the combined carbon and precipitating it as graphite, nickel tends to 'grey' iron and counteract the mottling effect, thereby producing an iron possessing good machining qualities; (2) owing to its function as a 'sorbitiser' of the pearlitic matrix, it produces a desirable resultant hardness; (3) it imparts toughness to chilled and white iron by somewhat restraining the chilling effect; (4) the transverse strength is somewhat reduced."

Summarising the *influence of chromium* in a similar manner, he says it is manifested by:—

"(1) Increased total carbon content; (2) increase in the combined carbon; (3) increase in the hardness; and (4) increase in the transverse strength with approximately 1.00 per cent., after which it drops off rapidly."

Fig. 1 shows the influence of nickel, chromium and silicon upon the total carbon content of cast iron.

The machining properties are not appreciably affected up to 0.80 per cent. chromium, above

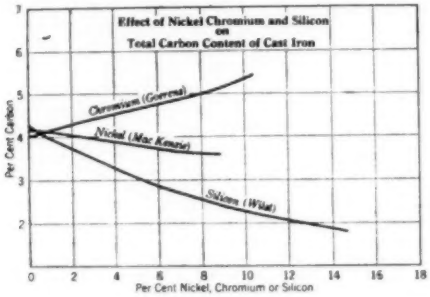

Effect of Nickel Chromium and Silicon on Total Carbon Content of Cast Iron
Chromium (Gowrad)
Nickel (Mac Kenzie)
Silicon (Wild)
Per Cent Carbon
Per Cent Nickel, Chromium or Silicon

FIG. 1.—HOW THE TOTAL CARBON CONTENT OF CAST IRON IS AFFECTED BY ADDITIONS OF NICKEL, CHROMIUM AND SILICON.

which, however, the machinability is decreased with increasing amounts of chromium. Machinability being a relative term, the figure 0.8 per cent. of chromium may be correct, but the present author is inclined to doubt the machinability of cast iron containing as much chromium as that, unless nickel were also present.

Due to its action as a stabiliser of the cementite, chromium is an essential constituent of cast iron which is subjected to heat. The hardening properties of chromium may be utilised when castings subject to abrasion are required.

The action of these alloying elements is undoubtedly influenced to some extent by the percentage of other elements present in the iron. One pictures the action of nickel as refining the grain and strengthening any ferrite or pearlite Similarly one knows that phosphorus, for example, increases the brittleness of an iron when present in quantity as phosphide. The inference is, therefore, that the toughening effect of the nickel on the grain proper would be counteracted, so far as mechanical properties are concerned, by high phosphorus contents, which would embrittle the grain boundaries. This has not yet been proved, however, so that experimentation with nickel additions appears justifiable even where only highly phosphoric iron is being melted. If nickel be added to a cast iron without decreasing the silicon, too grey an iron will probably be produced. If the silicon content be decreased somewhat, and nickel added, a grey iron with the graphite finely divided

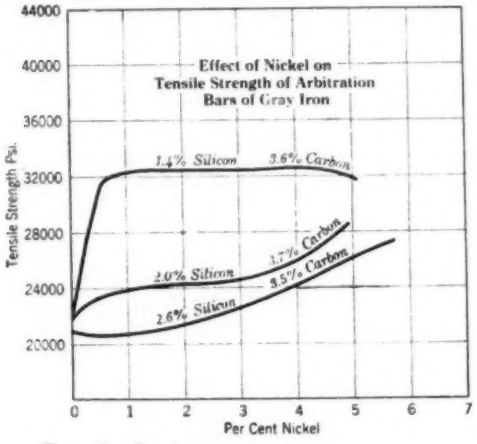


FIG. 2.—INFLUENCE OF NICKEL ON THE TENSILE STRENGTH OF STANDARD CAST BARS OF CAST IRON.

will result, giving improved mechanical properties, as may be seen in Fig. 2.

Machinable Hardness.

Tests reported by the staff of the International Nickel Company's Research Laboratory show that they have found with 4-in. by 4-in. castings, 5 in. and 8 in. long, that it is readily possible to secure almost any desired hardness, even at the centre of such heavy sections, up to 250 Brinell. At the same time the castings remain grey and readily machinable.

It is recommended, as a result of these tests, that if a maximum Brinell hardness is desired in cylinder castings with walls of the above thickness, addition of 3.0 to 3.5 per cent. Ni and about 0.7 per cent. Cr be made to an iron carrying approximately 3.0 per cent. total carbon and about 1.0 per cent. silicon. The hardness obtained by adding nickel differs from that due to variations in the carbon, silicon and sulphur contents. The nickel appears to increase the strength of the pearlite grains in the cast iron by changing them first to finer pearlite and later to sorbite. Graphite is still present, though usually smaller and more uniform in character, which explains why nickel can harden iron and yet leave it as readily machinable as before (see Figs. 3 and 4).

Reviewing some of the claims made for the effect of nickel upon various castings, one notes that some foundrymen maintain its most useful effect is in reducing porosity and making sound castings. Undoubtedly it increases the toughness, and to some extent the transverse, tensile and compression strength. It is universally said to

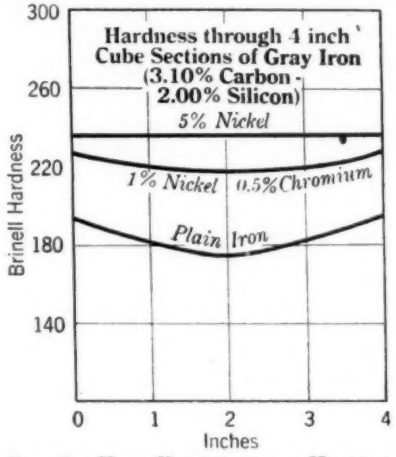


FIG. 3.—HOW VARIATIONS IN HARDNESS, THROUGH A 4-IN. CUBE OF GREY CAST IRON, ARE REDUCED BY NICKEL ADDITIONS. IRON TESTED HAD 3.1 PER CENT. C AND 2.0 PER CENT. SI.

increase the wear-resistance and hardness, while actually facilitating machining. This appears to be explainable on the basis that nickel equalises the hardness in different parts of a casting by decreasing the chill. Thus it helps the foundryman to control chill, *i.e.*, the amount of combined carbon, and to obtain the maximum machinable hardness by producing a grey iron with a fine-grained graphite and a pearlite which has been strengthened.

These effects may be partially or wholly masked by gross mistakes in the mixture, but they are probably present in any cast iron to which nickel is added. Cast iron is in itself such a complex and variable material that it requires careful adjustment of the amount of any additions of nickel and chromium to the grade and composition of iron used, as well as to the type and dimensions of the casting under consideration.

Some experimenting is almost always necessary before the best results are obtained, *i.e.*, before the alloy additions are made, in the quantities and manner most suited to any particular conditions.

This section may now be concluded by summarising the conclusions arrived at by Messrs. Wickenden and Vanick in the excellent Paper previously mentioned.

The principal useful effects of nickel, and suitable nickel-chromium additions to cast iron, have been proved to be:—

(1) 0.5 to 1 per cent. nickel with 0 to 0.5 per cent. Cr (the latter content depending upon the grade of the iron, more chromium being required with the higher silicon irons). (*a*) Increases the strength from 10 to 50 per cent. and (*b*) increases the Brinell hardness number by 20 to 50, without impairing machinability.

(2) Larger additions of the alloying elements enable one to obtain an increase of as much as 100 in the Brinell number, with the iron still machinable.

(3) 0.5 to 5 per cent. nickel (the amount depending on conditions) is able to reduce chilling on surfaces, sharp edges and corners, and to eliminate hard spots in castings made with comparatively hard iron, thus improving the machining properties.

(4) Additions of nickel (in this same percentage, 0.5 to 5 per cent.) increase the toughness and deflection, particularly of thin section castings.

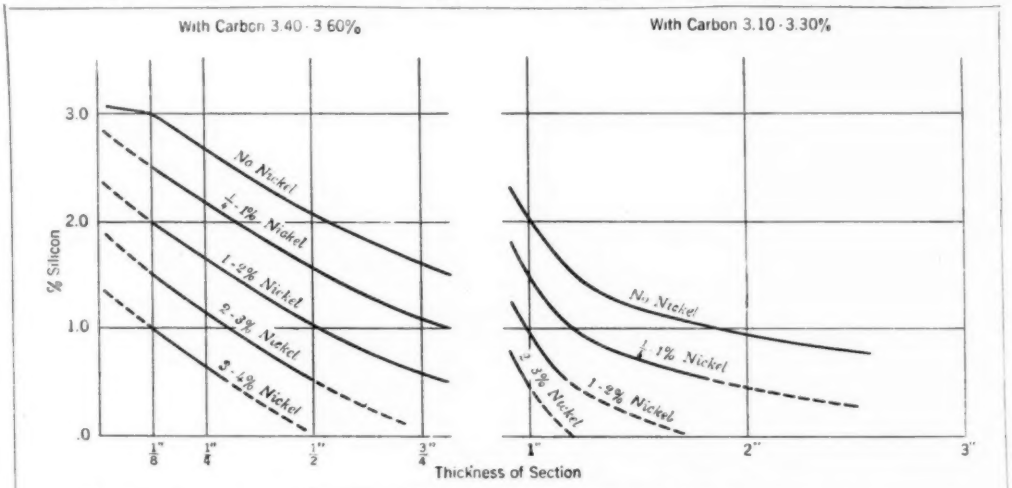


FIG. 4.—SILICON AND NICKEL PERCENTAGES REQUIRED TO MAKE CASTINGS OF DIFFERENT SECTIONS COMPLETELY GREY AND MACHINABLE.

(5) 0.15 to 1.0 per cent. nickel, together with small percentages of chromium if desirable, produces less porous castings and effects a grain refinement.

(6) Such alloy additions tend to equalise the hardness and strength figures over castings of irregular section or of large size.

Extent to which Ni-Cr Alloy Cast Irons are Now Being Used.

In the plants visited, typical American pig-irons were being melted, and the fact that such irons differ somewhat in analysis from many of those used here may be the reason why little nickel has so far been added to the normal run of cast iron in this country. If, on the other hand, foundrymen do not use nickel through having tried unsuccessful methods of making the addition, or through having made no suitable adjustment of the silicon or other constituents in their mixtures, the author points out that he has met quite a large number of practical foundrymen and works superintendents in America who were enthusiastic about their success on making nickel and nickel-chromium additions.

Automobile Castings.

For instance, one enthusiast asserted that 90 per cent. of the American automobile cylinder castings contained nickel or chromium. It is impossible to check such a statement, and it is probably only true in the same sense that 90 per cent. of our steel contains some nickel these days, which it acquires from the scrap added to the furnace charge. It is nevertheless an impressive fact that twenty-five of the American automobile manufacturers are known to make intentional additions of nickel or chromium to their cylinder mixtures. It has been estimated that 10,000 tons of nickel and nickel-chromium cast irons would be made in this manner in America in 1926. Nickel is added to other than cylinder block castings. The Cadillac Motor Company's works is undoubtedly one of the most businesslike foundries the author has visited, and he was told that they added 1.5 to 2 per cent. of nickel to their piston castings. This has produced a harder iron which machines as easily without heat-treatment as the former softer metal did with heat-treatment before machining. The present nickel cast-iron pistons are machined to an excellent finish; much superior to that of the former softer iron. Furthermore, the new nickel-cast-iron pistons have a superior resistance to abrasion in service. Formerly, an iron containing 2.30 per cent. Si had been used, and heat-treatment had been necessary to render the thin sectional pistons machinable.

The use of nickel was observed in large internal-combustion engines, being made in the Westinghouse Works at Philadelphia for railway work. These cylinder liners were made with a 20 per cent. steel addition (T.C. 3.35, Si 1.40, and Ni 0.5 per cent.), and the addition of the ½ per cent. of nickel improved the machinability by removing hard edges and carbide spots without appreciably altering the graphite content or hardness. After adding this nickel content to the otherwise unchanged mixture, it was noted that the iron took on a glaze more rapidly than before.

Diesel Engine Iron.

One of the most promising developments in grey-iron castings in the U.S.A. at the present moment is the use of nickel and nickel-chromium additions for the liners, pistons and cylinder heads of Diesel engines. The designers of these engines have constantly sought castings with the maximum hardness and wear resistance consistent with ready casting and machining. Specifications for such liners now actually call for hardnesses as high as 200 Brinell.

Most of the manufacturers have therefore been experimenting with alloy additions, and one well-known company now uses an iron made up with about 50 per cent. of steel scrap and nearly 1 per cent. of nickel, and about 0.33 per cent. of chromium (Si 0.65, S 0.16, and Mn 0.80 per cent.), the Brinell hardness number being over 200.

Diesel-engine liners for U.S.A. Government use have been made in the form of centrifugal castings containing ½ per cent. of nickel. (Silicon, 1.1 to 1.3; total carbon, 3.0; combined carbon, 0.80; S, 0.12; Mn, 0.35 to 0.4; and P, 0.20 per cent.)

The sections cast range from ½ to 2 in. in thickness, and must have 180 to 210 Brinell hardness.

For cylinders of thicker sections, say 2½ to 4 in., a greater percentage of nickel must be added to secure maximum Brinell hardness. For such heavy castings 3.0 total carbon, 1.0 silicon, 0.7 chromium, and 3.0 to 3.5 per cent. nickel has been recommended, as a result of a series of tests.

(To be continued.)

AUGUST'S MUFFLE FURNACES, LIMITED, of Halifax, have been entrusted by the Admiralty with the supply of the annealing and other furnaces to be incorporated in the extension of the steel foundry at Portsmouth Dockyard.

MR. R. GASCOIGNE, after many years' service with Thos. W. Ward, Limited, Thames Road, Silvertown, London, E.16, has severed his connection with the company. His duties will, in future, be taken over by Mr. Joseph Matthews and other members of the Silvertown staff under the control of the manager there, Mr. H. G. Faull.

XUM

The Giessler-Poumay Cupola.

As recently announced in our columns, the firm of Messrs. C. F. R. Giessler, of 58c, Gray's Inn Road, have just placed on the British market an improved system for the economic melting of cast iron in the cupola. The system is based on the complete suppression of carbon monoxide in the gases which finally escape from the cupola. In their publicity matter the following table appears which demonstrates this point. Samples of the gas were taken at seven levels, starting at the melting zone and finishing 10 in. below the level of the charging door:—

Sample Taken at Plane No.	CO_2 per cent.	CO. per cent.	O_2. per cent.
1	12. 4	10. 5	2.83
2	12. 5	8. 5	1.63
3	14.13	7. 0	0. 4
4	16.10	6. 1	0. 2
5	17.00	5. 4	0.16
6	17.90	1.26	0.03
10 in. below charging door	18.70	Nil	0.80

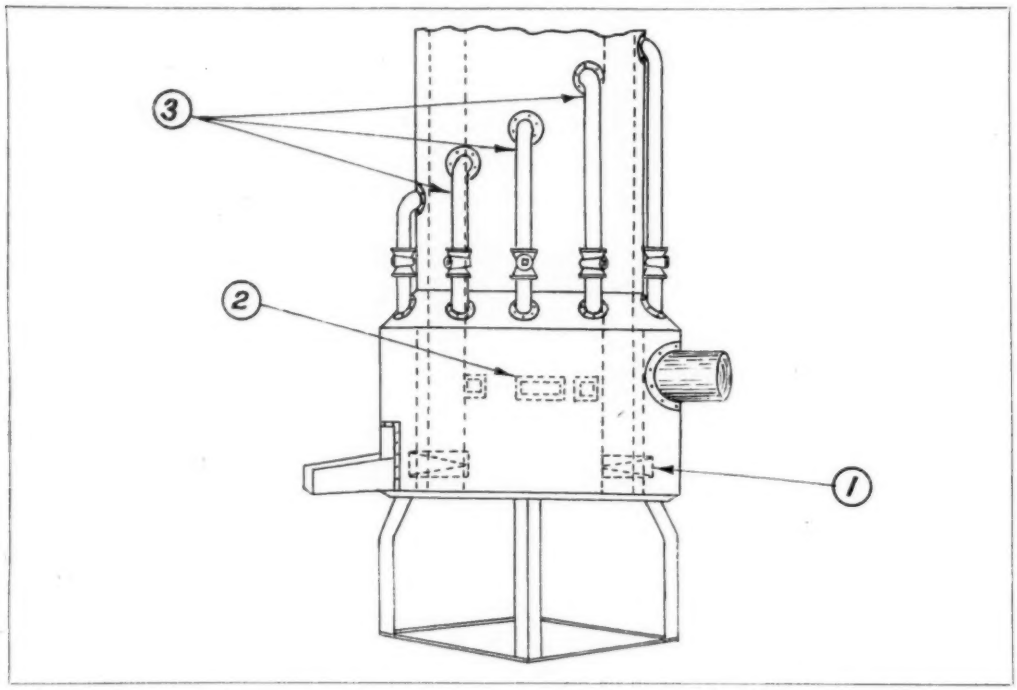
Dr. Piwowarski* gives for a normal composition of the furnace gases for a standard cupola 10 ft. above the tuyere level CO_2 12.4 per cent.; CO, 10.8 per cent.; and O_2, 1.25 per cent. Gas analyses relating to cupola practice are of such paramount interest that we hope that the methods adopted for the sampling will be made available for British trade. It is thought that the gases creeping up the lining of the furnace may be of a different composition from those which pass centrally through the body of the coke. However, it is more than probable that they would be taken under similar conditions to those used by Dr. Piwowarski, and would be thus comparable.

A further claim is made for less oxidising conditions, and in support figures are submitted which show that in a cupola, before altering to the Poumay-Giessler system, there was a 13 per cent. loss in silicon, and a 16 per cent. loss in the manganese content.

The tests are stated to be an average of two months, and presumably the same mixture gave before transforming C 3.25, Si. 1.76, and Mn, 0.72 per cent., and after the change over, C 3.06, Si. 2.0, and Mn. 0.79 per cent. A very interesting point arises as to why there is less carbon pick-up associated with higher Si. and Mn. contents.

The method of accomplishing this economy is by installing a series of small tuyeres with the object of forming a melting zone of reduced depth accompanied by a heavy generation of CO. These are shown at (1), Fig. I. There is a second series of tuyeres of still smaller cross-section, which form two branches. One of these is directed towards the centre, and the second is arranged tangentially. These are indicated at (2), Fig. I. Finally, there is a series of tuyeres arranged specially around the cupola. Their object is to ensure the complete conversion to CO_2 in the area which they serve, by raising the temperature somewhat through the combustion of the coke in this vicinity. This system claims a minimum economy of 25 per cent. over the normal coke consumption of any standard cupola, and they are certainly borne out by a number of glowing testimonials from Belgian and French users.

* F.T.J., Vol. 30, page 308, Fig. 7.



British Metallurgist for Australia.

Major A. Rhydderch sailed last Saturday from Liverpool for Australia, where he is to be associated with Hadfields (Australia), Limited. Major Rydderch was at one time in the research laboratories of Hadfield's Sheffield steel foundries, where he was engaged upon investigations into the properties of foundry sands. Afterwards he was appointed a director of Messrs. Robert Hyde & Son, Limited, of Chesterfield and Sheffield, where he supervised the Abbeydale Foundry. For some time past he has been foundry manager to Messrs. Lake & Elliot, Limited, of Braintree. He is a prominent member of the Institute of British Foundrymen, before which Association he has contributed several useful papers.

THE EMPLOYEES of A. Reyrolle & Company, Limited, Hebburn-on-Tyne, have contributed £969 to various hospitals and other institutions, through their Hospitals and Charities Committee, during the past year.

THE IMPERIAL CHEMICAL INDUSTRIES, the great chemical merger formed by the amalgamation of Brunner, Mond & Company, Limited, Nobel Industries, Limited, the United Alkali Company, Limited, and the British Dyestuffs Corporation, Limited, under the chairmanship of Sir Alfred Mond, Bart., M.P., is to make its first appearance to the public at the British Industries Fair organised by the Department of Overseas Trade at the White City from February 21 to March 4 During the past few weeks the staffs of the respective companies have been collaborating in the organisation of the largest individual exhibit which will be placed in the Chemical Section of the Fair. The main object of the exhibit is to make an expression of Imperial Chemical Industries' individuality as one group, at the same time showing the inter-connection of the different companies comprising the merger.

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Trade Talk.

FERGUSSON, WILD & COMPANY, LIMITED, have removed to 15, St. Helen's Place, London, E.C.3.

A FIRE WHICH BROKE OUT in the neighbouring works of Chambers, Scott & Company, Motherwell, Lanarkshire, practically destroyed the premises.

No. 1 AND No. 3 blast furnaces at the Devonshire Works of the Staveley Coal and Iron Company were relighted on January 7 after 35 weeks' stand.

FIRE BROKE OUT on January 5 at the works of W. C. Holmes & Company, Limited, ironfounders, of Turnbridge, Huddersfield, but only a tarred wooden building was destroyed.

JAMES GORDON & COMPANY, LIMITED, Windsor House, Kingsway, London, W.C.2, have started the manufacture in this country of the propeller type turbines, patented by the Swedish A/B Finshyttan.

JOSEPH KAYE & SONS, LIMITED, Lock Works, Leeds, have recently received a large repeat order from the Great Western Railway for their automatic carriage-door wedge locks, complete with combined cam-striking plates.

THE COMMITTEE OF MANAGEMENT of the London Iron and Steel Exchange has arranged for the annual dinner of the Exchange to take place at the Savoy Hotel, Strand, W.C.2, on Tuesday, February 8. The chair will be taken by Mr. H. J. Skelton, chairman of the Management Committee.

TWO OF THE largest trucks used by the London and North-Eastern Railway carried from Darlington to Middlesbrough Docks on Sunday a web-plate weighing 120 tons for the new bridge over Sydney Harbour. The web-plate was placed on two 60-ton trucks, one behind the other. A large break-down crane accompanied the trucks, to lift the plate at certain points so that it could be propped up for passage between the platforms at stations.

FOR THE PURPOSE of shipping Cleveland iron ore to their Jarrow undertakings, Palmers Shipbuilding and Iron Company, Limited, are credited with the intention of restoring the quays at the seaside village of Port Mulgrave. The company are the owners of the Grinkle ironstone mine, and years ago used to convey to Port Mulgrave the ore they required, and load it in small coasting vessels, which carried it to the Tyne. The service was often interrupted, and the firm eventually abandoned it in favour of rail transport. It is reported to be their intention to revert in part or wholly to the method of carrying by sea, and to restore the quays and ore-loading appliances at Port Mulgrave. The Grinkle mine is expected shortly to be in readiness for the drawing of stone. Messrs. Bolckow, Vaughan's South Skelton mine was reopened on Monday, and the men are signing on for work at Messrs. Dorman, Long, and Company's Kilton mine.

IN ADDITION to the Hams Hall power station contract mentioned in our last issue, International Combustion, Limited, have an order as main contractors for the Perak Hydro-Electric Power Station, being responsible for all buildings, cranes, boilers and pulverised fuel equipment for the 12,000-kw. station to be constructed in the Malay Peninsula. The company have also been awarded a contract by the Anglo-Persian Oil Company for an extension of the boiler-house plant at their Abadan Refineries, Persia. This contract covers the supply of water-tube boilers, the combustion chambers of which will be constructed to "Lopulco" designs, including the water cooling of the front wall. The boilers will be fired by means of oil fuel exclusively, but air pre-heating is to be used, the "Usco" plate type pre-heater having been specified for this purpose. A further contract covers the supply of the "Raymond" pulverising and transporting equipment for the firing of a continuous billet reheating furnace of 6 tons per hour capacity for a steelworks in the North of England.

THE GENERAL ELECTRIC COMPANY, LIMITED, have secured, from the Birmingham Corporation, the contract for the whole of the power-house equipment for the new Birmingham Hams Hall Power Station, in conjunction with the International Combustion Company, Limited. The General Electric Company's contract includes two 30,000 kw. turbo alternators, with condensers, two 1,875 kw. house service turbo generators with condensers, two house motor generator sets, the complete e.h.t., h.t. and l.t. switchgear equipment and transformers, and the whole of the power-house cabling. The value of this contract is some £500,000, and practically the whole of the machinery required will be manufactured at the engineering works of the General Electric Company, Limited, at Witton (Birmingham) and Erith. It is interesting to note the main item in the contract is two large turbo generators of 30,000 kw., which will be the sixth and seventh large sets manufactured by this company for the Birmingham Corporation, the previous five sets having been installed during the past four years at the Corporation's station at Nechells.

JOHN WOOD & SONS, LIMITED, Barley Brook Foundry and Engineering Works, Wigan, announce that their Newcastle agents, Charles Crofton & Son, have changed their address from 25, Pilgrim Street, Newcastle-on-Tyne, to 11, Marden Road South, Whitley Bay. Messrs. Wood have appointed Mr. Cyrus J. Evans, of Arlington, Sketty, Swansea, as their representative in the South Wales district.

DURING THE PAST YEAR the General Electric Company, Limited, Magnet House, Kingsway, W.C.2., have been entrusted with many important electrical contracts presenting features of special interest, while steady research and development work has also been in progress at the firm's Wembley research laboratories. In connection with photometry, an automatic machine has been constructed for the voltage rating of electric lamps by colour-matching of two photo-electric cells of different sensitivities. This machine eliminates the human eye factor in routine photometry, and enables an observer to rate 200 vacuum lamps per hour with a mean error of 0.13 per cent. in volts. Considerable advances have been made in X-ray spectroscopy, and the following are some of its recent applications: (*a*) *Metallurgy.*—The mechanism of preferred orientation of crystal fragments during the working of metals has been studied in the case of tungsten, by the examination of ingots in various stages of swaging. (*b*) *Refractories.*—The constitutional changes occurring in clays on heating have been investigated, and it has been shown that mullite and not sillimanite is formed in clays at 1,000 deg. C. Failures in refractories are regularly diagnosed by X-ray methods, and these are also used to established schedules for the firing of refractories. Turning to the heavy engineering side of the company's activities, recent contracts comprise orders from the Adelaide Municipality for a 22,000 k.v.a. turbo-alternator, 6,600 volts, 3-phase, 3,000 r.p.m., a similar set for the Birmingham Corporation, and an 8,000 k.v.a. turbo-alternator, 3-phase, 3,300 volts, complete with switchgear, for an Australian colliery, also a large number of other turbo-alternators. The G.E.C. has also received large orders for rotary and motor converters, transformers and switchgear for overseas requirements, and important municipalities and industrial undertakings in this country. An important development in connection with the distribution of electricity is the introduction of the G.E.C. transformer steel plate kiosk sub-station, which is specially designed for installation on high-tension alternating-current networks up to 11,000 volts, and supply circuits having a maximum capacity of 300 k.v.a.

Gazette.

In London, last week, the statutory meetings of creditors and shareholders were held in the compulsory liquidation of Gwynne's Engineering Company, Limited, of the Hammersmith Ironworks. The Official Receiver said the winding up order was made on October 13 last, a receiver and manager having been appointed on July 6, 1923, on behalf of the debenture holders. The statement of the company's affairs was prepared as at the date of his appointment, and disclosed gross liabilities £919,009, of which the sum of £713,879 was returned as expected to rank for dividend, there being 557 unsecured creditors with claims amounting to £533,321. The gross value of the assets was £200,894, but with the exception of £1,335, required to meet prefential payments, this amount was wholly needed to pay in part the claims of the debenture-holders, of whom there were 766. The claims of these holders, with interest, reached a total of £379,617. It was decided to leave the liquidation in the hands of the Official Receiver.

AT A meeting of Halley's Industrial Motors, Limited, in Glasgow, for the purpose of passing a resolution to wind up the company, Mr. G. Wingate, who presided, stated that the immediate and pressing reason for the company's going into liquidation was that the creditors had taken steps to enforce payment and that proceedings against the company were pending in the Courts. In the circumstances liquidation was the only course open so as to protect the interests of all concerned. Turning to the question of capital reorganisation he said it was proposed to ask the creditors to accept a cash composition of 5s. in the £, and accept six per cent. cumulative preference shares for the balance. The loans from bankers at £112,000 would be continued to the new company, and the bankers had agreed to grant a moratorium as to interest for two years, but this was conditional on the scheme of reconstruction being agreed to. The eight per cent. five-year noteholders would be asked to convert their securities into six per cent. preference shares, the inducement being the right to convert into ordinary shares during the next five years. The resolution was carried, and Mr. J. Ench was appointed liquidator.

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IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—Pig-iron production in the Cleveland area continues in steadily increasing volume. There are now some 42 furnaces in blast in the district, but the quantity available for market purposes is quite negligible, the bulk of the output being fully absorbed by local works having already large contracts booked on this account. Consequently consumers find it difficult to obtain needful urgent supplies, and business in the meantime is more or less impracticable. Some inquiries have been received, but it is doubtful whether anything can be done until the price of Cleveland iron comes down. Continental No. 3 can be done, it is reported, at something like 80s. per ton f.o.b., so that even in the most favourable circumstances the balance is still against Cleveland iron. In last week's markets there was no alteration in quotations. No. 3 G.M.B. is 85s. per ton, or 82s. 6d. over three or six months. No. 1 is still very scarce, and commands a premium of 5s. per ton over the No. 3 price. No. 4 foundry is 84s., and No. 4 forge 83s. 6d. per ton. Export prices are 6d. per ton more. In the hematite section supplies are coming forward a little more freely, but the quantity available for the market is still very small, and the price of mixed numbers remains very firm at a minimum of 90s. per ton. On the North-West Coast Bessemer mixed numbers are now quoted at £4 15s. 6d. per ton, delivered at Sheffield, and low-phosphorus iron at 5s. per ton higher.

LANCASHIRE.—Demand for foundry pig continues satisfactory, but supplies for prompt delivery are all but inaccessible at the moment. East Coast makers are offering Cleveland No. 3 for delivery into the Lancashire district at round 97s. 6d. per ton. For Scottish iron from 110s. to 112s. 6d. is about the current range of delivered prices.

THE MIDLANDS.—In the various districts of South Staffordshire consumers experience some difficulty as yet in obtaining ready supplies of foundry pig, but, as most of the furnaces are again producing, the inconvenience may be regarded as only of temporary duration. Meantime it will soon be possible to get delivery of various brands of No. 3 and No. 1 foundry iron from Derbyshire, Northants, Staffordshire and Cleveland districts, and hematite from the West Coast is already coming through, though so far none of the East Coast hematite makers have put any iron on to the market.

SCOTLAND.—With the prospect of an early revival of industrial activity on Clydeside, the pig-iron market has hardly responded as might have been expected, but smelters are experiencing difficulty in getting their furnaces on to the proper quality of iron required, and for this reason No. 3 foundry is still short in supply, and the prices are firm at from 90s. to 95s. at the furnaces.

Finished Iron.

In most producing districts of this class of material manufacturers report a steady improvement in the conditions prevailing, and in South Staffordshire many of the local makers will soon have their forges in operation. At the present time the basis price for crown quality is about £12 5s. per ton. It is, however, possible to get crown iron from outside the district at 15s. per ton less, but even at the lower figure not a great deal of support is forthcoming. The iron market remains very quiet. The makers of marked bars are very well engaged, and have a considerable leeway to make up, their price now being quoted at £14 10s. at works. With regard to the cheaper qualities of iron, little business is coming through, as the Continental price is so much below the figure which English makers can quote.

Scrap.

While business in iron and steel scrap is now steadily expanding, the fact that considerable undelivered balances remained to be delivered after the strike has tended to obscure the real market position. In Cleveland the works are not yet willing to pay more than 70s. per ton delivered for heavy steel scrap, though sellers take the view that this figure is on the low side. Machinery cast-iron scrap is still selling freely at 79s. to 80s. per ton, and ordinary cast iron at about 76s. In South Wales heavy cast-iron scrap, in large pieces and furnace sizes, has a good, steady demand, and is firm at 67s. 6d. to 70s. Good machinery scrap, broken in foundry sizes, has a quiet local demand, but is firm at 70s. to 75s. Heavy cast-iron lumps continue in demand in Yorkshire, but for the rest there is only a quiet inquiry, and prices all round are unchanged. Scottish heavy cast-iron scrap, suitable for steelworks and in furnace sizes, is still being inquired for around 72s. 6d. to 75s. per ton, but only small lots are being picked up at these prices. Heavy machinery cast-iron scrap, suitable for foundries and in pieces not exceeding 1 cwt., has eased off a little. The price is around 83s. 6d. per ton. Ordinary cast-iron scrap to the same specification is 5s. per ton less. Old cast-iron railway chairs remain unchanged around 83s. 6d. per ton.

Metals.

Copper.—There is but little demand by consumers, while inquiries on Continental account remain in narrow compass, as usual at this time of the year. Home buyers have postponed orders for the present. Considerable interest is being taken in the American situation, and it is now argued that the operations on the part of the export combine have failed to result in any improvement and even to stabilise the price, which is the aim of the combine.

Official closing prices of standard copper have been as follow :—

Cash : Thursday, £56 7s. 6d. to £56 10s.; Friday, £56 2s. 6d. to £56 5s.; Monday, £55 15s. to £55 17s. 6d.; Tuesday, £55 10s. to £55 12s. 6d.; Wednesday, £55 7s. 6d. to £55 10s.

Three Months : Thursday, £57 2s. 6d. to £57 5s.; Friday, £56 15s. to £56 17s. 6d.; Monday, £56 10s. to £56 12s. 6d.; Tuesday, £56 2s. 6d. to £56 5s.; Wednesday, £56 to £56 2s. 6d.

Tin.—The immediate lack of confidence is indicated by the present price. Strength will be gained, however, from the depreciation of stocks in this country, and in the statistics for December, which, showing an increase of only 747 tons in the total visible supply, are rather better than had been anticipated. Demand on the part of consumers has been poor, both in this country and on the Continent, but the reports received from the United States of America indicate only a moderate call for the metal.

Official closing prices of standard tin have been as under :—

Cash : Thursday, £299 10s. to £299 15s.; Friday, £299 15s. to £300; Monday, £301 15s. to £302; Tuesday, £299 15s. to £299 17s. 6d.; Wednesday, £298 to £298 5s.

Three Months : Thursday, £295 10s. to £295 15s.; Friday, £294 10s. to £294 15s.; Monday, £296 7s. 6d to £296 10s.; Tuesday, £294 10s. to £294 15s.; Wednesday, £293 5s. to £293 10s.

Spelter.—The trade demand has been generally poor, this being attributed to the slackness of business with galvanisers. Lately the market has been the turn easier, but there is no pressure to sell, and the market is talked better in some quarters. The market has come under the influence of the depression from which all metals have been suffering, and which, broadly speaking, must be ascribed to poor demand on the part of consumers and the uncertain outlook pending more normal conditions in the coalfields.

The following are the week's prices :—

Ordinary : Thursday, £31 16s. 3d.; Friday, £31 15s.; Monday, £31 12s. 6d.; Tuesday, £31; Wednesday, £30 10s.

Lead.—In regard to soft foreign lead, it is an open secret that some 15,000 tons of foreign has been carried on the London market, and although it is believed to be in strong hands, prices since the opening of the year have further weakened to within a few shillings a ton of the lowest point touched last year for prompt delivery. There has, so far, been little indication of any revival of buying, although this week home cable makers ordered about 300 tons for February arrival at £28 15s., c.i.f. The Continental demand has remained very light, but Germany having recently resold a good quantity to Russia, there is now less pressure of offers from the Continent.

The week's prices are appended :—

Soft foreign (prompt) : Thursday, £28 1s. 3d.; Friday, £28 2s. 6d.; Monday, £27 16s. 3d.; Tuesday, £27 10s.; Wednesday, £27 7s. 6d.

Obituary.

MR. WILLIAM ROBERTSON, who for almost 50 years was foundry foreman at the Grahamston Iron Works, Falkirk, died on January 8, at the Falkirk and District Infirmary. Deceased, who was 81, served his time to the moulding trade in a Falkirk foundry, and with the exception of a period of seven years in Glasgow (at the Saracen Foundry and at the Sun Foundry) he spent most of his days in his native place.